DEPARTMENT OF COMMERCE AND LABOR

BULLETIN

OF THE

BUREAU OF FISHERIES

VOL. XXVII

1907

GEORGE M. BOWERS, Commissioner

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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By MICHAEL X. SULLIVAN, Ph. D.

BUREAU OF FISHERIES DOCUMENT NO. 625.

THE PHYSIOLOGY OF THE DIGESTIVE TRACT OF ELASMOBRANCHS.

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INTRODUCTION.

The digestive tract in fishes has been studied quite extensively both from the histological and from the physiological standpoint. Most of this work has been done on European species, however, and has given rise to contradictory conclusions, especially from the viewpoint of physiology. Hence it seemed advisable to devote some attention to fishes found also in American waters, and I have accordingly undertaken the study of the digestive tract of elasmobranchs.[a]

This group of fishes was chosen for investigation, first, because of the relatively simple structure of their digestive tract, and second, because they may, from their position in the scale of evolution, form the groundwork for an extensive comparative study of fish in general. Thus we may arrive at a unified view of the changes, structural and physiological, which have taken place in the alimentary canal of fishes from the lowest to the highest. The treatment of the subject is partly histological, but mainly physiological.

HISTORICAL DISCUSSION.

THE DIGESTIVE TRACT IN FISHES.

MORPHOLOGY.

As in higher animals, the digestive tract in fishes may be divided into the following portions: Mouth, esophagus, stomach, small and large intestine. In fishes, however, two or more of these divisions may coalesce and become indistinguishable. As a rule there is a complicated dentition, but no salivary glands. The buccal cavity opens directly into the esophagus, and this in turn into a large stomach.

[a] The work embodied in this paper was done at the laboratory of the U. S. Bureau of Fisheries, Woods Hole, Mass. during the summers of 1905 and 1906, when the writer was a salaried assistant of the Bureau. I am indebted to Dr. W. L. Chapman for making the photomicrographs of the rectal gland (plate I).

which is usually furnished with a valve at its posterior end. The digestive tract may be straight, U-shaped, or Y-shaped—straight in *Branchiostoma* and the cyclostomes; syphonal or U-shaped in the elasmobranchs and in some teleosts, where the stomach presents the form of a bent tube, of which one half is the cardiac and the other the pyloric portion; cæcal or Y-shaped in most teleosts, where the cardiac division is a long, descending blind sac, with the cardiac and pyloric openings of the stomach lying close together. In most cases the pyloric tube is long and slender.

In many fishes, especially among ganoids and teleosts, a variable number of blind tubes open into the intestine immediately posterior to the pylorus. These tubes are termed the pyloric cæca and are often filled with the same material as is the intestine. When present in large numbers, the appendages often coalesce into a common duct. In the cyclostomes and dipnoans no pyloric appendages exist, and in the elasmobranchs pyloric cæca have been found by Turner (1873) only in the Greenland shark, *Læmargus borealis*, and by Gegenbauer (1892) in certain skates.

The duodenum receives the hepatic and the pancreatic secretions, and also the secretion of the pyloric appendages.

The intestine varies much in length, and in many fishes the absorbing surface is increased by folds of the mucous membrane, which wind spirally or are arranged in parallel lamellæ. These spiral valves are found in cyclostomes, selachians, ganoids, and dipnoans. In short, the digestive tract in fishes varies greatly, from a simple condition to a complex one, with valves, folds, and appendages.

The pancreas is the most constant of all digestive glands in vertebrates. In the lower fishes it occurs as a compact mass, while in the teleosts it is, as a rule, diffused and distributed about the pyloric cæca, hepatic duct, and in the liver. The presence of the pancreas in bony fishes in a widely diffused state was demonstrated by Legoius (1873). In the elasmobranchs the pancreas is comparatively large, and pinkish in color. It empties by a single duct into the duodenum.

Cæcal appendages at the end of the intestinal canal are of exceedingly rare occurrence in fishes. In the elasmobranchs, however, an appendage, the so-called rectal gland, exists near the end of the intestine. This gland varies from half an inch in length in the skate to three or four inches in the big sharks. According to Wiedersheim (1905, p. 422), cloacal appendages exist in the dipnoans and traces of a blind intestine may be found in certain teleosts, while in the Holocephali the place of the rectal gland is taken by glandular tissue within the walls of the rectum.

For a more detailed account of the gross anatomy of fishes the reader is referred to Home (1814), who described the intestines of thirty species, and to Rathke (1824), who described fifty-six species. General works on the intestinal canal of fishes are Siebold and Stannius (1854), Milne-Edwards (1860), Günther (1880), Oppel (1896, 1897, 1900, 1904), and Wiedersheim (1905).

HISTOLOGY.

Though Nehemiah Grew (Gamgee, 1893) made mention, in 1676, of a glandular secretion in the stomach of the horse, it was not until 1836 that the gastric glands were actually discovered. In this year Boyd (1836) discovered gastric glands in mammals and noticed their presence in some fishes. Following Boyd, Bischoff (1838), one of the earliest workers on the histology of the alimentary canal in fishes,

studied the mucous lining of the stomach of a great many species. In Cyprinidæ he was unable to find gastric glands. In other species, however, he found them abundant. As we shall see later, the lack of gastric glands is not peculiar to the Cyprinidæ, since many other fishes have no functional stomachs.

Rathke (1841) found that the alimentary canal of *Amphioxus* (*Branchiostoma*) is composed of ciliated epithelium without glands, and Johannes Müller (1843), in his work on the myxinoids, arrived at the same results. By these investigators the simplicity and uniformity of the mucous lining of the alimentary canal in the lower fishes was fully established.

Vogt (1845) proved the existence of two kinds of cells in the stomach of the common trout, *Salmo fario*, i. e., cells of cylindrical epithelium, covering the surface, and round cells in the crypts. Vogt, however, did not recognize these crypts as gastric glands. Leydig (1852), on the other hand, clearly recognized the gastric glands in *Squatina angelus* and in *Torpedo galvani*, since he writes of the small round cells, containing highly granular protoplasm, as granular cells. In 1853 Leydig found such glands in the sturgeon, *Acipenser nasus*, but could not find them in the stomach of the loach, *Cobitis fossilis*. In a still later paper Leydig (1857) referred to these glands as "labdrüsen," thus signifying that they were like the gastric glands of higher vertebrates.

Since 1857 much work has been done on the histology of the alimentary canal of fishes, and especially on the histology of the stomach. Perhaps the best reviews of previous work are presented by Edinger (1877), Richet (1878), and Yung (1899). To the works of these authors I am greatly indebted.

One of the earliest workers on the glands of the stomach of fishes was Valatour (1861), who noticed the presence of gastric glands in various species and confirmed Bischoff's work in that he could find no functional stomach in Cyprinidæ. From 1861 to 1870 much advance was made in histological technic, and in 1870 Heidenhain discovered two kinds of granular cells in the mammalian stomach, and Rollet the same year confirmed his discovery. These cells are now known as chief and parietal cells. In fishes, on the other hand, Edinger (1877) could not find the two kinds of gastric cells distinguished by Heidenhain and Rollet in the mammalian stomachs. Of Edinger's work we may speak in detail.

Edinger (1877) made a detailed histological study of the entire digestive tract of fishes. According to his investigations, the stomachic crypts are only partly lined with gastric glands, for in the pylorus the crypts are functional merely as mucous glands. The pyloric appendages are simply evaginations of the intestinal wall and present the same structure as the part from which they arise. Properly speaking, no glands exist in the middle intestine, and the mucous cells are the only secretory part. The other epithelial cells are merely absorptive in function. Finally Edinger paid much attention to the question as to whether or not chief and parietal cells exist in fishes. He concluded that there is only one kind of cell in the gastric glands—a cell which is homologous to neither of these cells.

Edinger's conclusion has been generally accepted, although several authors have noted differences in the cells of the gastric crypts. Thus Cajetan (1883) called attention in the case of *Cobitis barbatula* to the fact that the cells of the stomach differ with respect to the dimensions of their granules and their staining reaction to osmic

acid. Pilliet (1894) also mentioned some differences between the gastric cells of *Pleuronectes* according as they are situated at the superficial or the deeper portions of the gland.

Pilliet studied principally selachians and *Pleuronectes*. According to him, the glands of the stomach of the selachians are long. In *Pleuronectes* he noted a difference in the extent of the distribution of the glands, in that they are fewer in young or undeveloped fish. He likewise claimed that the cardiac portion of the stomach of *Pleuronectes* is essentially peptic, while the pyloric portion is essentially mucous.

According to Cattaneo (1866), who studied numerous fishes, the fishes highest in the scale of evolution repeat in their development the structure of the digestive tract as found successively in adult acraniates, cyclostomes, selachians, and ganoids. The least differentiated part of the intestine of the higher forms has a structure like the most differentiated part of the lower forms. Like Edinger, Cattaneo found in all species of fishes that the stomach and middle intestine are the most differentiated parts, while the esophagus and terminal intestine preserve a primitive character. With Edinger, he concluded that only one kind of cell is present in the gastric glands of fishes.

In addition to the writers already mentioned, Macallum (1886) described the intestines of some ganoids, Decker (1887) studied fresh-water fish, while W. N. Parker (1889), Hopkins (1890, 1895), Mazza (1891), Mazza and Perugia (1894), Claypole (1894), and Haus (1897) have added to our detailed knowledge of the digestive tract in fishes. More recently Yung (1899) made a detailed study of the digestive tract of *Scyllium canicula*, while Oppel (1896, 1897, 1900, 1904), in his "Lehrbuch der vergleichenden mikroskopischen Anatomie der Wirbelthiere," has made a comprehensive review of the previous work on the microscopical anatomy of the digestive tract.

PHYSIOLOGY.

The first experiments on the digestion of fishes were made by Spallanzani (1783), who worked on eels, pikes, carps, and barbels. Previously, Réaumur (1752) and Stevens (1777) had worked respectively on birds and man. Réaumur, indeed, made the first decisive step in the physiology of digestion. He introduced into the stomach of a kite small metallic tubes with the ends covered by a grating of threads or fine wire. He found that the gastric juice is acid and that it would digest meats and bones, but not vegetable grains or flour. Stevens proved the same thing for man, and in addition proved that the gastric juice would digest in vitro. Spallanzani in like manner passed into the stomach of his fish tubes filled with flesh, and, having left them in the stomach forty-two hours, found them covered with mucus, but with little or no flesh within them. From this work Spallanzani concluded that digestion is carried on best in the fundus of the stomach. He believed, however, that the stomach is not the only part capable of digesting food, but that the esophagus, in a more feeble way, also has digestive power. He likewise believed that digestion is accomplished without trituration, for the thin tubes which he used did not show any trace of deformation.

Spallanzani also showed that digestion goes on in vitro as in the stomach; consequently, hypotheses regarding vital force, coction, and fermentation have no reason to exist. Digestion is, on the contrary, a chemical phenomenon, not a process

of putrefaction. Furthermore, this investigator saw that the acid is secreted by the stomach and that it might be seen exuding from the walls. He did not make mention, however, of digestion in the intestines or of the action of the bile. In his eyes, indeed, the stomach in all animals was the principal digestive organ.

Tiedemann and Gmelin (1827) made observations upon the contents of the intestinal tract of the trout, barbel (*Cyprinus barbus*), etc., and proved that in a fasting fish the mucus does not redden litmus, but that a stomach full of food contains free acid and coagulates milk. Tiedemann and Gmelin believed that the acidity is due to a mixture of acetic and hydrochloric acids. These workers also paid some attention to the liquid of the pyloric appendages. This liquid, they found, reddens litmus but slightly, and they believed that it mixes with the food dissolved by the stomach and accelerates assimilation.

In 1873 Fick and Murisier called attention to the fact that the ferment in the stomach of the trout and the pike differs from that of higher animals in that it digests food at a low temperature as well as at 40° C., while the higher organisms digest better at the higher temperature.

In the same year Rabuteau and Papillon (1873) recognized that the gastric juice of the skate is acid, and the former writer secured, by distillation, a colorless liquid which he considered hydrochloric acid.

A little later Homburger (1877) concluded from his researches upon *Cyprinus tinca*, *Chrondrostoma nasus*, *Scardmius erythrophthalmus*, and *Abramis brama* that the bile and extracts of the liver of these animals, as well as extracts of the intestinal mucous membrane, digest fibrin, emulsify fats, and convert starch to sugar.

In 1877 Krukenberg carried on investigations upon the intestines, and then upon the glands connected therewith, of widely different species belonging to all classes of fishes except dipnoans. From this work he concluded as follows:

No fish possesses salivary glands, although some have a diastase in the mucous membrane of the mouth, as, for example, *Cyprinus carpio* and *Lophius piscatorius*.

The action of the stomach is variable. With some selachians, ganoids, and teleosts this organ secretes pepsin similar to that of mammals in that it acts only in an acid medium, but different in that it can act at a lower temperature. In some cases, as in certain teleosts (*Zeus faber*, *Scomber scomber*), the stomach produces pepsin only in its anterior part, while the fundus secretes a mixture of pepsin and trypsin or a juice capable of digesting fibrin in an acid or in an alkaline medium. With other teleosts (*Gobius*, *Cyprinus*) the stomach, or the organ, considered as such does not furnish any enzyme at all. Digestion in these instances is carried on exclusively in the middle intestines.

In the selachians and the ganoids pepsin is produced not only in the stomach, but also in the anterior end of the middle intestines, in the selachians to the place where the pancreatic duct empties, and in the ganoids to the pyloric appendages.

In the selachians the massive pancreas secretes trypsin, while in the ganoids and teleosts, which have a diffused pancreas mixed with hepatic tissue, a ferment similar to pepsin can be extracted from the liver. This ferment is absent from the liver of the selachians.

In the case of the Cyprinidæ trypsin is found both in the liver and in the mucous membrane of the middle intestine. The middle intestine, indeed, should be regarded as the principal seat of digestion in these fishes.

As regards the function of the pyloric appendages in most fishes, they inclose only mucus and chyle and are absorbing organs, while in other cases they secrete either a trypsin-like ferment, as in the *Thymnus vulgaris*, a mixture of pepsin and trypsin, or sometimes a mixture of pepsin, trypsin, and diastase.

Finally, in many species the liver, or hepato-pancreas, and the middle intestine secrete a diastatic ferment, as does even the buccal mucous membrane.

The general tendency of Krukenberg's studies, therefore, is to establish the existence of an evolution of the digestive function from the invertebrates (molluscs, crustacea, etc.) to the higher vertebrates. By the great variation in the distribution of the ferments, fish, according to him, show the principal stages of this evolution.

Luchhau (1878), by means of glycerin extracts of the mucous membrane of the stomach of the salmon, pike, and sandre, secured juices that would peptonize fibrin. Contrary to Fick and Murisier (1873), he observed that the peptonizing action is more rapid at 40° C. than at 15° C. Luchhau also examined the digestive activity of the juice of certain Cyprinidæ (*Cyprinus carpio*, *C. blicca*, *C. carassius*, *C. tinca*, *C. erythrophthalmus*, and *Abramis brama*), which do not have a functional stomach. In no case did he find an enzyme digesting in an acid medium—that is, pepsin; but he did find that fibrin is digested by the neutral or alkaline extract of the intestinal mucous membrane and that the digestive power is greater at 40° C. than at lower temperatures. Luchhau compared the ferment of the intestines of Cyprinidæ to the trypsin of mammals, and in addition to the trypsin-like ferment he found the diastatic ferment also. The trypsin-like ferment, he asserted, is secreted in the middle region, while the diastatic ferment is secreted along the whole length of the intestine. He did not find a fat-splitting ferment, nor, unlike Krukenberg, did he find any ferment which would digest albumen.

In researches upon the composition of the gastric juice, Richet (1878) analyzed the gastric juice of different fishes. He proved conclusively the presence of hydrochloric acid, free or combined with organic substances, such as tyrosin and leucin. He found the acidity to be high, in the case of *Scyllium canicula* even as high as 1.5 per cent hydrochloric acid. The digestive power of *Scyllium canicula* he found to be greater than that of *Lophius piscatorius*. In a later paper Mourrut and Richet (1880) found that the liquid in the stomach lost its digestive power by filtration. An acidity of 2.5 per cent was found by them to prevent peptonization, while moderate heat favored the action of the ferment. Mourrut and Richet did not observe that either *Lophius* or *Scyllium* produced a diastatic ferment in the stomach.

In a still later study of digestion in fish, Richet (1882) confirmed the facts previously given by him and declared that the gastric juice of sharks digests the chitin of crustacea. Further, the pancreas of *Scyllium* and of *Galeus* has no action on proteids but is limited to the transformation of starch to sugar and to the emulsification of oil.

Raphael Blanchard (1882) investigated the rectal gland of elasmobranchs and the pyloric appendages of teleosts. He found that the former organ produces both a diastatic and a fat-splitting ferment. The pyloric appendages, according to this investigator (1883), represent, in a certain sense, the pancreas, since they secrete a diastatic enzyme and a trypsin-like enzyme.

The presence of the trypsin-like ferment in the pyloric appendages has been proved also by W. Stirling (1884, 1885), who worked on the herring, cod, and hake, and made glycerin extracts of the stomach and pyloric appendages. In the stomach he found a ferment acting in acid and in the pyloric appendages one acting in an alkaline medium, from which observations he concluded that the stomach secretes pepsin, the pyloric appendages trypsin.

Decker (1887) found the stomach of fish to be sometimes neutral, sometimes alkaline, and he likewise found that the esophagus of the hake digested fibrin much more rapidly than the stomach did. He found in these species, moreover, that the esophagus, the intestine along its whole length, the cloaca, and the pyloric appendages all produced a ferment comparable to pepsin.

According to the researches of Knauthe (1898) all the intestinal mucous membrane of the carp, and especially the anterior portion of the intestine, produces a strong tryptic ferment, as does also the liver, or hepato-pancreas. The intestinal mucous membrane, except that of the mouth and the hepato-pancreas, produces amylolytic and fat-splitting ferments. The bile, he concluded, has of itself no digestive action on proteids or fats mixed with extracts of the intestinal mucous membrane or of the hepato-pancreas; it augments their action. The bile has, however, a diastatic action which is at the maximum at 23° C.

Bondouy (1899) investigated the function of the pyloric tubes in teleosts and came to the conclusion that they played an active part in digestion. They secrete trypsin and amylopsin, but no lipase. On the other hand, Bondouy believed the pyloric tubes have but little function as absorptive organs.

Yung (1899) in a very comprehensive and detailed work on elasmobranchs, including *Scyllium canicula*, *Acanthias vulgaris*, *Lamna cornubica*, *Galeus canis*, and *Carcharias glaucus* found that—

(1) The buccal and esophageal membranes have no digestive action.
(2) The stomach digests proteids.
(3) The acidity of the stomach may be as high as 1 per cent.
(4) The stomach may or may not convert the food into anti-peptone.
(5) The gastric juice of *Scyllium canicula* acts better at 38° C. than at 20° C.
(6) The formation of pepsin is limited to the stomachic sac.

Very little study has been given to the physiology of the pancreas of fishes. Bernard (1856) proved that the pancreas of the skate converts starch to sugar and acidifies fats. Krukenberg (1877), in his work on selachians, found that the pancreas of these fishes was secreting trypsin, the proteolytic ferment, but no amylopsin, the starch-splitting ferment, nor lipase, the fat-splitting ferment. Richet (1878), however, was unable to find trypsin in the pancreas of selachians, but did find the starch-splitting and fat-splitting ferments. Yung (1899), working on *Squalus acanthias*, found amylopsin and lipase, but only occasionally trypsin. Yung attempted to get the juice by a fistula, but had little success. His water glycerin extracts were only occasionally active. He found that extracts of the spleen aided the activation of the pancreas. More recently, Sellier (1902) found that the pancreas of several selachians studied by him does not of itself digest proteid, but must be activated by the juice of the spiral valve.

From this synopsis of the literature, it may be seen that there is by no means unanimity of opinion regarding the physiology of the digestive tract of fishes.

OBSERVATIONS AND EXPERIMENTS.

HISTOLOGY OF THE ALIMENTARY CANAL OF THE SMOOTH DOGFISH AND THE SAND SHARK.

The intestine of both *Mustelus canis* and *Carcharias littoralis* is bent twice upon itself; the first of these bends is between the stomachic sac and the pyloric tube, the second between the pyloric tube and the middle intestine. From an anatomical standpoint these two bends divide the alimentary tube into three portions, of which the first two constitute the anterior intestine, the third the middle and terminal intestine. As a rule the middle intestine, or what we might call the duodenum, is short. In *Mustelus canis*, indeed, there is almost no duodenum or valve-free portion between the pyloric tube and the spiral valve. On the other hand, in *Carcharias littoralis*, *Carcharhinus obscurus*, *Dasyatis centrura*, *Lamna cornubica*, and *Tetronarce occidentalis*, the middle intestine, or duodenum, is well marked off from the spiral valve and pyloric tube. From a histological standpoint the entire intestine may be divided into buccal, esophageal, stomachic, pyloric, duodenal, valvular, rectal, and cloacal mucous membrane.

Upon the digestive tract of European selachians, as Yung shows in his paper, "Recherches sur la digestion des Poissons" (1899), considerable histological work has been done. Yung himself made a thorough study of the alimentary canal of *Scyllium canicula*. The histology of *Mustelus canis* and *Carcharias littoralis* is practically the same and agrees in most respects with that of the European form *Scyllium canicula*. Histological study of the digestive tract of the American species shows the following facts:[a]

BUCCAL MUCOUS MEMBRANE.

The mucous membrane of the buccal cavity is smooth, often covered with fine papillæ and moistened with mucus. Sections of the mucous membrane of the buccal cavity showed epithelium and connective tissue, but no glands. The epithelium is of the stratified pavement type. The epithelial cells next to the connective tissue are cylindrical, finely granular, and possess oval nuclei. Above this layer of cylindrical cells are several layers of large mucous cells, which are oval and contain a substance that stains with the ordinary mucus stains. The nucleus is very small, elongated, and pressed against the cell wall. Finally, the superficial epithelium consists of one or two layers of flat or oval cells which form a fine membrane.

MUCOUS LINING OF THE ESOPHAGUS.

Numerous papillæ and longitudinal folds occur in the inner lining of the esophagus. The folds are fine at their beginning, but thicken toward the cardiac end of the stomach. They vary in number and frequently anastomose. Transverse folds form a boundary more or less marked between the esophagus and the stomach. The mucous membrane of the esophagus is whitish, in strong contrast to that of the

[a] As fixing agent I used corrosive acetic, and as stain hematoxylin and eosin.

stomach, which is always reddish in color, especially noticeable when the stomach is full of food. In the beginning of the esophagus the epithelium is similar to that of the buccal cavity, but it is gradually replaced by an epithelium consisting of ciliated cylindrical cells and goblet cells.

MUCOUS MEMBRANE OF THE STOMACHIC SAC.

The mucous membrane of the stomach has a reticulated appearance, due to numerous folds. Some of these folds are continuations of the longitudinal folds of the esophagus, while others are transverse and oblique. In the pyloric tube the folds are extremely fine. Histologically, the mucous membrane of the stomachic sac differs from that of the esophagus by the absence of cilia and of goblet cells, and by the presence of true peptic glands.

The epithelium of the stomachic sac is of two kinds, superficial and glandular. The first is composed of a single layer of prismatic or pyramidal cells with oval nuclei. In these, two portions may be distinguished—one, finely granular, which incloses the nucleus and occupies four-fifths of the length of the cells; and another, the superficial part or the part nearest the cavity of the stomach, composed of a highly refractive, nonstaining, transparent substance. These two portions, as Yung (1899) has pointed out in his work on *Scyllium canicula*, corresponded to what Oppel (1897) called the protoplasmic portion and the upper portion. The refractive superficial portion of these cells has been called "Pfroph" or "plug" by Biedermann (1875), and is considered by Oppel as a substance comparable to mucus. The superficial epithelium, which is rather uniform in character, covers all the folds of the mucous membrane and the superficial portions of the glandular tubes.

The glandular tubes begin in the cardiac end of the stomach and extend to the pylorus, being most plentiful in the middle of the stomachic sac. Each gland is a cylindrical tube, with the canal narrow in the upper part but wider toward the bottom. The tubes in the middle of the stomach are longer than those of the cardiac end or the pyloric end of the sac. In every case they are separated from each other by a fine layer of connective tissue. The epithelium of the neck of the peptic crypts consists of cylindrical cells, like those of the superficial epithelium, which become little by little shorter and thicker. They are distinguishable from the superficial layer, however, by the absence of the mucous plug, and by the presence of a large round nucleus. They differ from the neighboring peptic cells by their clearer contour, smaller size, and the smaller amount of granulation. The body of the gland is occupied by cells which are irregularly polygonal in shape, highly granular, and closely packed together. These cells are all of one kind, and can not be differentiated into chief and parietal cells, such as Heidenhain and Rollet have found in the mammalian stomach.

PYLORIC TUBE.

In the long narrow pyloric tube we find crypts and the same superficial epithelium as in the stomachic sac. The crypts, however, are short and the polygonal peptic cells are absent.

INTESTINE.

The intestine of elasmobranchs may be divided into two portions—a small intestine or duodenum, and a large intestine. The former is short, varying from one-

half an inch to 2 inches in length. The latter is longer and very wide; it is divided into two portions—the colon, containing the spiral valve, and the rectum, which is short.

From the end of the pyloric tube to the cloaca the histology of the intestine is practically the same and consists essentially of cylindrical and goblet cells. No glands are present, but the villi project into the lumen of the intestine both in the duodenum and in the spiral valve. The epithelium which covers these villi is the same throughout and consists of cylindrical and goblet cells. Since the villi are more prominent in the spiral valve, it would be well to consider this part of the intestine in detail.

SPIRAL VALVE.

A spiral valve is present in the colon of cyclostomes, selachians, ganoids, and dipnoans. Its histological structure in *Mustelus canis* and *Carcharias littoralis* is like that of the duodenum. The villi stop abruptly at the point where the rectal gland opens into the intestines. The folds of the spiral valve are formed from the mucosa of the walls of the intestines. Through the middle of each fold passes the muscularis mucosa. From the center connective tissue extends into the villi. A cross section of a fold shows: (1) Epithelium of upper surface, (2) connective tissue, (3) connective tissue and muscular tissue, (4) connective tissue, (5) epithelium of undersurface.

RECTAL GLAND.

The rectal gland, glandula or processus digitiformis, is a compound tubular gland varying from one-half inch in the skate to four inches in the mackerel shark. It opens into the rectum by a duct, which, beginning at the central canal of the gland, runs forward along the edge of the mesentery to enter the dorsal wall of the lower end of the spiral valve or the top of the rectum. The gland consists of three layers: (1) an outer fibro-muscular layer, (2) a middle glandular layer, and (3) a central region consisting of ducts and blood vessels arranged round a central lumen.

The middle layer is composed of a number of branched tubules radially arranged and separated by capillaries which are usually gorged with blood. The high power shows mono-nucleated cubical cells not clearly defined from each other and of a glandular appearance.

The central layer begins at a varying distance from the periphery by the sudden transition of the gland cells into the epithelium of ducts which open into the central lumen. In many cases the more superficial cells have undergone a mucoid change and a band of clear cells is visible lining the duct. The microscopical appearance of the gland is shown in plate I.

PHYSIOLOGY OF THE DIGESTIVE TRACT OF ELASMOBRANCHS.

While studying the food of the dogfish, *Mustelus canis*, at the laboratory of the Bureau of Fisheries, Woods Hole, Mass., during the summer of 1904, Irving A. Field found that 16 per cent of the dogfish contained lobsters, 34.17 per cent rock crabs, and 20.1 per cent spider crabs. The carapace of these organisms consists of salts and chitin, the latter highly resistant to reagents. As the carapace was found in varying degrees of decomposition, and, further, since the carapace of crabs and

lobsters fed to the fish could not be found in the stomach after four days of digestion, the question arose as to whether the dogfish actually does digest chitin. I therefore began, during this summer, a physiological study of the alimentary canal of *Mustelus canis*. During the summers of 1905 and 1906 the investigation was extended to include *Carcharias littoralis*, *Squalus acanthias*, *Tetronarce occidentalis*, *Carcharhinus obscurus*, *Raja erinacea*, *Lamna cornubica*, and *Dasyatis centrura*. The work consisted of—

(a) The preparation, for artificial digestion, of extracts of buccal, esophageal, and gastric mucous membranes.

(b) The study of the normal content of the stomach.

(c) The study of the acidity of the stomach.

(d) Determining whether or not *Mustelus canis* digests chitin.

(e) The preparation of extracts of the intestinal mucous membrane and of the pancreas.

(f) The study of the activation of the pancreas.

(g) The study of the rectal gland.

BUCCAL CAVITY.

The elasmobranchs as a rule swallow their food whole, without mastication. Naturally we should suppose that little digestion goes on in the buccal cavity. This probability is increased by the absence of glands. Since Krukenberg (1877) claimed, however, that the buccal mucus of some fish, especially of *Cyprinus carpio* and *Lophius piscatorius*, possesses a diastatic action, it seemed proper to test the action of various kinds of infusions of the buccal mucous membranes of selachians.

The buccal cavity of a number of these fish, freshly killed, was scraped. The mucus thus collected was white in color, neutral in reaction, and gave a good test for mucin, but showed no diastatic activity. Scrapings of the buccal cavity of all the elasmobranchs obtainable gave the same results.

The buccal cavity of elasmobranchs, then, as Yung has already shown for *Scyllium canicula*, secretes mucin comparable to that of the saliva of man, but with no diastase.

Water extracts of the buccal mucous membrane have no permanent emulsifying action on olive oil.

Five-tenths per cent hydrochloric acid extracts of the buccal mucous membrane filtered free of mucin have no peptonizing action on white of egg or pig fibrin. The buccal mucous membrane then contains no pepsin-like enzyme.

Conclusions: The buccal mucus of all the elasmobranchs examined contains mucin but no digestive ferment.

ESOPHAGUS.

The reaction of the esophagus of a fasting fish is neutral. Tested when the fish is in full digestion, on the other hand, the reaction of the esophagus is acid, due, undoubtedly, to regurgitation from the stomach.

Mucus was scraped from the esophagus of ten fasting smooth dogfish. This mass was divided into two equal portions and one portion was made slightly alkaline with sodium carbonate, while the other was acidified to the extent of five parts of

hydrochloric acid in one liter. To each portion thymol was added to prevent the action of microbes. Into test tubes containing the alkaline and acid solutions, respectively, fibrin was placed. In no case was the fibrin digested, whether the tubes were kept at 18° C. or at 37° C.

Therefore the esophagus produces neither trypsin nor pepsin. If the mucous membrane is scraped from the esophagus of a fish in full digestion, extracts of this mucus may have a slight digestive action on fibrin in acid solution. This digestive action, however, is due to some pepsin which has come from the stomach, for if the esophagus is well washed before scraping the esophageal mucus is found to have no action on fibrin.

In like manner neither water extracts nor weakly alkaline extracts of the mucous membrane of the esophagus have any diastatic action on starch paste even after a lapse of ten hours. Yung (1899) in two cases found a diastatic ferment in the mucus of the esophagus. These cases were one *Scyllium canicula* in full digestion and one *Acanthias vulgaris*. He concludes from his experiments, however, that as a rule the epithelial elements do not produce a diastatic ferment.

Water extracts of the esophageal mucus have no action on olive oil.

Conclusion: The esophagus has of itself no digestive action.

MUCOUS MEMBRANE OF THE STOMACHIC SAC.

The mucous membrane of the stomachic sac was scraped and triturated in equal parts of glycerin and 0.5 per cent hydrochloric acid. Neutralized extracts did not coagulate milk. Therefore the rennet enzyme and its zymogen are absent from the mucous membrane of elasmobranchs.[a] The acid extracts digested uncooked white of egg and fibrin rapidly, but acted very slowly on cooked egg. As a rule the products of digestion by the acid extracts were peptones. Alkaline extracts of the stomachic sac showed no digestive activity.

The only proteolytic ferment in the stomachic sac of elasmobranchs is, accordingly, pepsin similar to that of higher vertebrates. There is one great difference, however, between the pepsin of mammals and that of fish: The pepsin of fish acts at a low temperature far better than does that of mammals. Moreover, Fick and Murisier (1873) and Hoppe-Seyler (1877, cited by Yung, 1899) claimed that the fish pepsin acts better at 10° C. or 15° C. than at 37° C. Luchhau (1878) and Yung (1899), on the other hand, observed that the peptonizing action of the stomach of fishes is greater at 40° C. than at 15° C.

While I should admit that the pepsin of fish acts rapidly on fibrin at 15° C., I must conclude from my experiments that the pepsin of *Mustelus canis*, *Carcharias littoralis*, and *Galeocerdo tigrinus* digested fibrin better at 37° C. than at 20° C. In this conclusion I am in exact agreement with Yung, who found in *Scyllium canicula* that the pseudopepsin of fish acted more rapidly at the higher temperatures. Before leaving the question as to the action of pepsin it must be said that the artificial digestion in no way approximates the natural digestion as carried on in the stomach,

[a] Certain experiments have led me to believe that the rennin zymogen (pexinogen) may exist in the mucous of the stomachic sac of at least some of the elasmobranchs and may be extracted by appropriate methods as the active enzyme rennin (pexin). To this question I hope to return at another time.

because in natural digestion the products are rapidly carried off, the stomach is in constant movement, and the pepsin and hydrochloric acid are constantly being renewed.

In no case, whether the solution was acid, neutral, or alkaline, did I find that glycerin extracts of the mucous membrane of the stomachic sac of the various elasmobranchs had the power of converting starch to sugar. In concluding that the mucous membrane of the stomachic sac of elasmobranchs does not produce a diastatic enzyme I should be in exact agreement with Richet (1882), who studied *Scyllium* and *Acanthias*, and with Yung (1899), who extended his studies further—to *Galeus* and *Lamna cornubica*. Upon ethyl butyrate, likewise, I found that the watery extracts had no effect whatever.

MUCOUS MEMBRANE OF THE PYLORIC TUBE.

Peptic glands are absent from the pyloric tube. To study the physiology of this tube, I took 10 smooth dogfish (*Mustelus canis*) and 10 sand sharks (*Carcharias littoralis*). After carefully washing the inner surface of the pyloric tube I scraped off the mucus and macerated it in glycerin and 0.5 per cent hydrochloric acid solution. After twenty-four hours the liquid was filtered. To the filtered liquid small pieces of fibrin were added. In twelve hours the digestion mixture was tested and showed syntonin, but no peptones. Contrary to Krukenberg's (1877) results from work on selachians, we must conclude with Yung that the formation of pepsin is limited to the cardiac end of the stomach or the stomachic sac.

The pyloric tube has likewise no action on starches or fats.

Conclusion: The only active ferment secreted by the stomach of elasmobranchs is pepsin.

CONTENT OF THE STOMACH.

The study of the content of the stomach is really the study of the content of the stomachic sac. The content of the stomach varies greatly. Sometimes it is strongly acid and viscid; sometimes it is liquid and holds in suspension alimentary débris, more or less recognizable, oil, fish in various stages of decomposition, chitin, etc.

An analysis was made of the contents of the stomachic sac of *Mustelus canis*, *Carcharhinus obscurus*, *Carcharias littoralis*, *Squalus acanthias*, *Tetronarce occidentalis*, *Raja erinacea*, *Lamna cornubica*, and *Galeocerdo tigrinus*. The acid content of the stomach was neutralized and an abundant precipitate of syntonin occurred. The filtrate was boiled, and if a precipitate occurred was again filtered. The solution was boiled and again treated with an excess of ammonium sulphate. The precipitate showed albumoses. The filtrate was then tested with the biuret reaction. As a rule syntonin, proteoses, and peptones were found in the stomach content. Occasionally, however, no peptone could be found in the stomach content of *Mustelus canis* and *Carcharias littoralis*.

Conclusions: The stomach of *Mustelus canis*, *Carcharias littoralis*, *Squalus acanthias*, *Tetronarce occidentalis*, *Carcharhinus obscurus*, *Raja erinacea*, *Lamna cornubica*, and *Galeocerdo tigrinus* secretes pepsin and converts proteids partly to antipeptone.

Acidity of the gastric juice.—Richet (1878) found the acidity of the gastric juice of fish to be much greater than that of mammals. Thus he found the acidity of fish he studied to be as follows:

Fish.	Parts in 1,000.
Skate (Raja clavata)	14.6
Lophius piscatorius	6.2
Squalus squatina	6.9
Scyllium catulus	6.9
Scyllium canicula	14.9
Pike	6.0

The acidity Richet found to be due to an acid not soluble in ether. He believed that the acid was hydrochloric acid combined with some organic substance, as leucin or tyrosin.

Yung (1899) in his study of the gastric juice of *Scyllium canicula* found the mean of four analyses to be 0.84 per cent.

The acidity of the stomach of elasmobranchs is greatest when the fish is in full digestion. Indeed, the fasting stomach is practically neutral. In order to study the acid, phenolphthalein, alizarin, and dimethyl-amido-azobenzol were used as indicators as recommended by Webster and Koch (1903) in their Laboratory Manual of Physiological Chemistry (p. 36), and experiments were made to determine: (a) The total acidity of the stomach content in terms of hydrochloric acid; (b) the physiologically active hydrochloric acid; (c) the free hydrochloric acid. The results are given in the following table:

Species.	Total acidity in percentage hydrochloric acid.	Physiologically active hydrochloric acid, average percentage.	Highest percentage free hydrochloric acid.
Mustelus canis	0.04–1.00. Average, 0.73. 50 individuals.	0.538. 6 individuals.	0.2.
Carcharias littoralis	0.1–1.2. Average, 0.87. 25 individuals.	0.614. 10 individuals.	0.31.
Squalus acanthias	Average, 0.67. 60 individuals.	No tests.	No tests.
Carcharhinus obscurus	Average, 0.55. 2 individuals.	0.493. 2 individuals.	0.254.
Lamna cornubica	0.275. 1 individual.	0.229. 1 individual.	0.172.
Galeocerdo tigrinus	0.93. 1 individual.	0.812. 1 individual.	None.
Tetronarce occidentalis	0.51. 1 individual.	No tests.	None.

In the case of *Carcharias littoralis* and *Carcharhinus obscurus* the physiologically active hydrochloric acid was determined as follows: (a) By neutralizing 10 c.c. of the stomach contents, evaporating, calcining, and finding the total chlorides by titrating with normal silver nitrate; (b) by evaporating, calcining, and finding, by titrating with the silver nitrate solution, the chlorides in a nonneutralized 10 c.c. of the stomach content; (c) subtracting (b) from (a). The results were as follows:

Total acidity in terms of hydrochloric acid (phenolphthalein indicator):

	Per cent.
Carcharias littoralis	1.1
Carcharhinus obscurus	.92

Physiologically active hydrochloric acid by $AgNO_3 = C$:

Carcharias littoralis	0.660
Carcharhinus obscurus	.525

Action of the gastric juice on chitin.—Lobsters and crabs form part of the food of several of the elasmobranchs. The shell of these crustaceous consists of chitin and salts. This chitin is very resistant to reagents. According to Hammarsten (1901), chitin, to which he gives the formula $C_{60}H_{100}N_8O_{38}+n(H_2O)$, is insoluble in boiling water, alcohol, ether, acetic acid, dilute mineral acids, and dilute alkalies. It is dissolved without decomposing in cold concentrated hydrochloric acid. Since chitin is so resistant it is interesting to know whether the chitin-eating fish digest chitin or whether it passes through the body unchanged.

An analysis of lobster shells given by Herrick (1895) from the work of Albert W. Smith is as follows:

TABLE SHOWING COMPOSITION OF THE CARAPACE OF THE LOBSTER (3 SPECIMENS).

Composition, air dried.	1.	2.	3.
Weight in grams	11.87	21.51	8.18
Calculated as calcium carbonate	[illegible]	[illegible]	[illegible]
Calcium phosphate	7.70	8.32	11.18
Calcium sulphate	.08	.53	.99
Magnesium carbonate	3.40	2.29	3.48
Sodium carbonate	1.41	1.80	2.31
Alumina	.68	2.04	1.04
Silica	.11	.29	.08
Organic matter and water	42.21	41.80	18.09

Richet (1878) believed that the chitin of the shell of crabs, lobsters, etc., is digested by dogfishes and sharks, although he recognized that it is extremely difficult to dissolve chitin by artificial digestion. Yung (1899), on the other hand, claimed that the selachians do not digest chitin, for he found pieces of chitin not only in the stomach but even in the spiral valve and rectum. More recently Zaitschek (1904) has proved quantitatively that the chitin in the wings of insects is absolutely undigested by hens.

To determine whether the elasmobranchs, and especially the smooth dogfish, digest chitin, the following experiments were made:

1. Several fishes were fed with crabs and lobsters and in the course of from one to five days were killed. In some cases the shells were found in the stomach in a macerated state. On the other hand, no compact chitin could be found after ninety hours of digestion, but in the spiral valve might be found a gritty dark-brown or reddish mud.

2. The gastric juice was drawn from several large dogfish. Into small quantities of this juice lobster shells were placed. The mixtures were kept at a constant temperature—some at 18° C., some at 38° C. After twelve hours the only change found in the shell was that the edges were softened a trifle.

3. The mucous membrane of the stomach of five dogfish was scraped, triturated in glycerin and 0.5 per cent hydrochloric acid. This juice, although it acted quickly on fibrin, did not digest the chitin in forty hours.

4. Experiment 2 was repeated with the difference that at frequent intervals the gastric juice was renewed and the chitin was subjected to frequent grinding. In this

way there was formed a pulverized mass of a dark brown or dark red color, which approximated the granular mass found in the intestines of the chitin-swallowing fish.

5. Pieces of chitin were placed in acid of strengths varying from 0.5 to 35 per cent hydrochloric acid. Carbon dioxide was set free in each case, but in greater quantities with the stronger acids. The chitin became softened, pliable, but did not dissolve.

6. Crabs were fed to dogfish confined in small aquaria. The excrement of the fish was carefully watched, and in this excrement, known by its shape and color, some pieces of the softened but otherwise unchanged chitin could be found. No evidence was gathered that the fish ever regurgitated any of the chitin, though Yung believes that regurgitation might take place.

Conclusion: The conclusion to be drawn from the experiments is that *Mustelus canis* and other chitin-swallowing fishes do not digest the chitin. The frequent change of the gastric juice, combined with the movements of the stomach, dissolves out the salts, softens the shell, and breaks it up into a fine mass, such as may be found in the spiral valve. The chitin is not regurgitated, but on the contrary is excreted in a finely divided mass.

MIDDLE INTESTINE.

Extracts of the middle intestine or duodenum of the various elasmobranchs show no digestive activity. Whether or not the cylindrical cells and goblet cells lining the mucous membrane of the duodenum play any part in activating the pancreatic juice will be discussed under pancreatic digestion.

SPIRAL VALVE.

Extracts of the mucous membrane of the spiral valve showed no digestive action on starches, fats, or proteids; nor indeed was it possible to demonstrate any inverting power, though we may presume that such power may exist in this mucus. The main function of the spiral valve is absorptive. Its further action in pancreatic digestion will be taken up in the discussion of the function of the pancreas.

PANCREAS.

As may be seen by reference to page 9, there has been but little experimentation on the pancreas of fishes, which fact is warrant for discussing the physiology of the pancreas of elasmobranchs. In order to get at the problem with the greatest clearness, it would perhaps be well for us to outline the growth of knowledge concerning pancreatic digestion, from the first experiments on the pancreas to the later researches leading to our present-day understanding of the action of this organ.

The pancreatic ducts, according to Haller (1764), were discovered by Wirsung in 1642. Although Wirsung appears to have observed the pancreatic juice, he did not pursue the subject further, and little was made of his discovery until Regner De Graaf took up the matter. In 1664, De Graaf, according to Foster (1901), made the first successful pancreatic fistula and collected the juice from a dog. But De Graaf did not obtain a definite grasp of the function of the pancreas. Eberle (1834), however, announced that a watery infusion of the pancreas when shaken with oil emulsifies it. In 1836, according to Corvisart (1857), Purkinje and Pappenheim discovered the proteolytic power of the pancreas, and nine years later Bouchardat and Sandras (1845) discovered and established with precision, by means of observation

carried on with the aid of pancreatic infusions as well as of small quantities of pancreatic juice obtained from hens and geese, that this secretion possesses powerful diastatic properties.

As pointed out by Gamgee (1893, p. 203), this discovery of the sugar-forming enzyme of the pancreas has been erroneously attributed to Valentin (1844). Valentin recognized that starch was changed, but did not say that the change was a conversion to sugar. His own words are: "Wie man sieht erlauben diese Erfahrungen noch keine irgend bestimmenden Schlüsse. Höchstens deuten sie darauf hin, dass vielleicht die Pancreasflüssigkeit die Fähigkeit habe die Stärke löslich zu machen und beweilen eine Umsetzung derselben einzuleiten." No further study of the pancreas seems to have been made until Bernard took up the work.

Bernard (1856), by means of a pancreatic fistula, proved that the secretion is an alkaline fluid with a threefold action on starches, fats, and proteids. He concluded, however, that the pancreatic juice alone has no action upon proteids, but that it is able to dissolve them either when they have been first of all subjected to the action of bile or when it acts in conjunction with bile. To this proteolytic function of the pancreatic juice, indeed, Bernard gave little weight.

In 1857 Corvisart called attention to the proteid-digesting power of the pancreatic juice, and although his observations were more or less discredited by some, they were confirmed by Meissner (1859), Danilewsky (1862), and Kühne (1867), the latter particularly contributing greatly to our knowledge of tryptic digestion.

The great interest awakened in the proteolytic activity of the pancreas by the researches of Kühne (1867) was intensified by the publication of a remarkable memoir by Heidenhain (1875). In this paper the author described for the first time those changes in the secreting cells of the pancreas which correspond to the different states of activity, and announced that the fresh pancreas does not contain the proteolytic ferment, but an antecedent body which he called zymogen. This zymogen he found could be extracted from the gland, and under suitable treatment would yield the proteolytic ferment. Since Heidenhain's discovery the antecedent bodies of other enzymes have been discovered. To the antecedent of the proteolytic enzyme of the pancreas, trypsin, the name trypsinogen has been given.

As a result of the study of the pancreas by the various investigators, this organ has long been known to secrete an alkaline juice and three enzymes or their zymogens, namely, trypsin, acting on proteids; amylopsin, acting on starches; and steapsin or lipase, acting on fats. Notwithstanding all the study of the pancreatic juice, however, in many ways the knowledge of its action was somewhat uncertain. Sometimes the pancreatic extracts would show a little digestive power, while the juice collected by a fistula was, as a rule, inactive. To explain these variations, investigations were made on the correlation between the pancreas and other organs and juices. Heidenhain (1875) had observed that when an aqueous solution of dried pig's bile was added to a glycerin extract of the pancreas, the proteolytic power of the latter was increased. Chittenden (1885) noticed that bile in a pancreatic extract containing salicylic acid increased tryptic action. Martin and Williams (1890) and Rachford and Southgate (1895) also noticed the stimulating action of bile on tryptic digestion. Chittenden and Albro (1898), however, found that normal bile exerts very little influence on pancreatic proteolysis and may retard as well as aid. Bruno

(1899), on the contrary, found that the bile even doubled the action of the pancreas, and that this action was not lost by boiling, and Delezenne (1902) verified, in the main, Bruno's work, but declared that bile does not activate inactive pancreatic juice. What part the bile plays in activating the pancreas is not yet fully decided.

The spleen has also been claimed to play a certain part in digestion. Schiff (1862), Gachet and Pachon (1898), Bellamy (1901), and Mendel and Rettger (1902) have shown that the spleen when congested during digestion increases the proteolytic power of the pancreas. On the other hand, Heidenhain (1883), Ewald (1878), and Hammarstein (1901) do not find that the spleen had any action on pancreatic digestion, while Noel Paton (1900) has shown that there is not necessarily any difference in the nitrogenous metabolism of dogs before and after splenectomy. Frouin (1902) has demonstrated that the removal of the spleen from dogs with an isolated stomach does not interfere with their nutrition even during a meat diet. Further, Camus and Gley (1902), Bayliss and Starling (1903), and Hekma (1904) have shown that extracts of the spleen have no activating action. The influence of the spleen on pancreatic digestion is still open to debate.

An activating principle more easy of demonstration is that discovered by Dr. N. P. Schepowalnikow (1898) in the succus entericus, or the juice of the small intestines. This juice, though possessing no proteolytic action itself, has the power of augmenting the activity of the pancreatic ferment, and especially of the proteolytic ferment—trypsin. Indeed, it was found that the succus entericus would convert an otherwise inactive pancreatic juice into an active juice. To the ferment, since such the activating principle was found to be, Pawlow gave the name of enterokinase. Others have corroborated Schepowalnikow's work, and Delezenne (1902) found enterokinase not only in the duodenum, jejunum, and slightly in the ileum, but also wherever leucocytes abound. In other words, he claims that the activating principle is generated by the white blood corpuscle.

From the size of the pancreas in the elasmobranchs we should expect this organ to play a large part in the work of digesting food. Krukenberg (1877), in his work on selachians, found that the pancreas of these fishes was secreting amylopsin, steapsin, and trypsin. Richet (1878), however, was unable to find trypsin. More recently Yung (1899), working on *Squalus acanthias*, found amylopsin and lipase, but only occasionally trypsin. Yung attempted to get the juice by a fistula, but had little success. His water glycerin extracts were only occasionally active. He found that extracts of the spleen aided the activation of the pancreas. Sellier (1902) found that the pancreas of several selachians studied by him does not of itself digest proteid, but must be activated by the juice of the spiral valve.

To determine just what part the pancreas of selachians plays in digestion and what enzymes it secretes, my work comprised experiments as follows:

1. Pancreatic fistulæ were made to obtain pure pancreatic juice.
2. Water glycerin extracts and sodium carbonate extracts were made to extract the zymogens or enzymes.
3. Extracts of the pancreas were combined with bile, and with extracts of the duodenum, spiral valve, spleen, stomach, and rectal gland.
4. The fresh pancreas was used to determine the presence of lipase.
5. The content of the spiral valve was studied.

Pancreatic fistulæ.—In order to collect the pancreatic juice a slit was made in the abdomen and in the wall of the duodenum of *Carcharias littoralis* in such a way as to cut the pancreatic duct. Into the central end of the duct was fastened a small glass cannula. To the outer end of the cannula was fastened a small sterilized rubber balloon. After the sand shark had been sewed up it was set free in a large aquarium. In a few days the balloon was taken off and the juice collected with a pipette. As a rule the quantity of juice thus collected was small and had no digestive activity. Owing to the difficulties of keeping the fish alive for a prolonged period and of feeding them, I made but six fistulæ and then abandoned this kind of work for the pancreatic extracts.

The proteolytic enzyme. Activation of the pancreas.—The pancreas was ground in a mortar with glass, and the comminuted mass was treated with water and glycerin. After twenty-four hours the mixture was filtered through cotton. To test the digestive activity of the extracts, at first I used Mett's tube and fibrin. Finding both of these media unsatisfactory, I employed Fermi's (1902) gelatin method, using 10 per cent gelatin and 0.6 per cent carbolic acid. The gelatin was placed in small test tubes and the upper layer of the gelatin marked on the tube by means of a blue pencil. The amount digested was measured in twenty-four hours if the experiment was carried on at the room temperature; in three hours if at 37° C. The pancreatic extracts had as a rule very little digestive activity. Accordingly, I added water glycerin extracts or water chloroform extracts of the mucous lining of the stomachic sac, pyloric tube, duodenum, spiral valve, rectal gland, and spleen to determine whether or not any of these extracts would activate the pancreas. Controls were made in each case. The results may be found in the table.

TABLE SHOWING THE ACTIVATING ACTION OF THE VARIOUS EXTRACTS UPON TRYPTIC DIGESTION.

Species.	Pancreas.	Pancreas duodenum.	Pancreas spiral valve.	Pancreas rectal gland.	Pancreas spleen.	Pancreas bile.
Carcharias littoralis	0 or +	0 + or ++	+++	0 or − [a]	+	+; — ++ [b]
Carcharhinus obscurus	0 or +	++	+++	0 or +	0 or +	0 or −
Lamna cornubica [c]	0 or +	?	++	?	?	
Mustelus canis	0 or +	0 + or ++	+++	0 or +	0 or +; ++ [d]	—; ++ [b]
Squalus acanthias	0 or +	0 or +	++	0 or +	0 or +	0 or +
Raja erinacea	+	+	++	0 or +	0 or +	0 or +
Dasyatis centrura	0		++	0	0	0

Species.	Bile.	Duodenum.	Spiral valve.	Rectal gland.	Spleen.	Pancreas and stomachic sac.	Pancreas and pyloric tube.
Carcharias littoralis	0	0	0	0	0	+	+
Carcharhinus obscurus	0	0	0	0	0	+	+
Lamna cornubica [c]	0	0	0	0	0	0	0
Mustelus canis	0	0	0	0	0	0	0
Squalus acanthias	0	0	0	0	0	0	0
Raja erinacea	0	0	0	0	0	0	0
Dasyatis centrura	0	0	0	0	0	0	0

+, quantity digested by pancreas.
++, greater quantity.
+++, still greater quantity.
0, no digestion.
—, less than pancreatic extract alone.
[a] Only a few tests were made to determine the activating action of the rectal gland.
[b] The bile often increased the proteolytic activity of the pancreas, but occasionally diminished this activity.
[c] Only two sets of experiments were made.
[d] The spleen occasionally showed activating action.

The conclusions to be drawn from the table are:

(1) The pancreatic extracts may or may not show proteolytic activity.

(2) The duodenum as a rule causes the inactive pancreatic extract to digest the gelatin and increases the digestive activity of an active pancreatic extract.

(3) The greatest activation is produced by the spiral valve.

(4) The spleen occasionally activates the pancreatic extract.

(5) The bile sometimes activates, sometimes has no effect whatever, and sometimes slightly diminishes the digestive activity of the pancreatic extracts.

(6) Extracts of the duodenum, spiral valve, and rectal gland have no digestive activity.

(7) The bile alone has no digestive power.

(8) Extracts of the rectal gland have no activating influence.

(9) Extracts of the mucous membrane of the stomachic sac and pyloric tube have no activating action.

Amylopsin and lipase.—Krukenberg (1877), Richet (1878), and Yung (1899) found amylopsin and lipase in the pancreas of European elasmobranchs. To determine the presence of these enzymes in the pancreas of the American elasmobranchs experiments were made (1) on the amylolytic activity and (2) on the lipolytic activity.

1. Water-glycerin extracts of the pancreas, slightly acidified with acetic acid, were made at different times from different lots of fishes. To 5 c. c. of a starch paste, free from sugar, was added 5 c. c. of the extract. After a short period the mixture was examined for sugar by Fehling's test. If negative, the tests were repeated at hourly intervals for six hours. In every case control tests were made. The results of the experiments are as follows:

Species.	Diastatic enzyme (amylopsin).	
	Number of tests.	Positive.
Carcharias littoralis	6	4
Carcharhinus obscurus	2	2
Lamna cornubica	2	0
Mustelus canis	10	6
Squalus acanthias	2	1
Raja erinacea	10	0
Tetronarce occidentalis	1	1
Dasyatis centrura	1	1

The table shows that the pancreas of elasmobranchs may secrete the diastatic enzyme or its zymogen. Even in the case where the tests were negative I should expect on further investigation to find that the pancreatic extracts have the power to convert starch to sugars.

2. To determine the presence of the lipolytic ferment of the pancreas, the fresh pancreas of *Mustelus canis*, *Carcharias littoralis*, and *Raja erinacea*, the only elasmobranchs available at the time, was used. The methods employed and the results obtained are as follows:

(a) The fresh pancreas of the three fish mentioned was cut finely and mixed separately with a little water to make a thin paste. To a small quantity an equal volume of olive oil and litmus solution was added, and this mixture was kept at 30° C. for

twenty-four hours. When a small quantity of a 1 per cent sodium carbonate solution was added to the oil mixture a permanent emulsion was formed in every case. When olive oil alone was treated with water and sodium carbonate the emulsion was not permanent.

(b) A neutral ethereal solution of butter was made and litmus added to a distinctly blue tint. This was placed in contact with a teased bit of fresh pancreas, as recommended by Gamgee (1893, p. 213). In a short time the liquid bathing the pancreas became faintly pinkish in spots, showing that a slightly acid reaction had developed.

(c) Aqueous extracts of the pancreas separated a small amount of butyric acid from a dilute solution of ethyl butyrate.

From these experiments it is to be concluded that lipase is secreted by the pancreas of *Mustelus canis*, *Carcharias littoralis*, and *Raja erinacea*, although its activity as demonstrated in vitro is not very great.

RECTAL GLAND.

Blanchard (1882) studied the function of the rectal gland, or digitiform gland, in *Acanthias vulgaris*, *Mustelus canis*, *Scyllium catulus*, *Scyllium canicula*, *Raja punctata*, and *Raja maculata*. In every case he found that extracts of the gland emulsified oil and converted starch to sugar, but had no action on white of egg or cane sugar. Extracts made by me of the rectal gland, or processus digitiformis, of *Carcharias littoralis*, *Carcharhinus obscurus*, *Lamna cornubica*, *Mustelus canis*, and *Raja erinacea* had no digestive action on fibrin or starch, nor did they hydrolyze ethyl butyrate. In the secretion of the gland I found considerable mucin. To the structure and physiology of the rectal gland I shall return in a later paper. At present, however, I should decide that the rectal gland has no digestive activity.

SUMMARY.

The results of the histological work in the present investigation may be summarized as follows:

1. The mucous membrane of the bucal cavity of *Mustelus canis* and *Carcharias littoralis* consists of stratified epithelium, with goblet and cylindrical cells, but no glands.

2. The mucous membrane of the esophagus possesses ciliated cylindrical cells and goblet cells, but no glands.

3. Gastric crypts exist in the stomachic sac of the elasmobranchs. There is no differentiation into chief and parietal cells. The epithelium of the crypts consists of cylindrical cells and polygonal cells.

4. The pyloric tube has the same kind of superficial epithelium as the stomachic sac and similar crypts. The polygonal cells, however, are absent.

5. The epithelium of the intestines from pyloric tube to cloaca consists of cylindrical cells and goblet cells.

6. The rectal gland is a compound tubular gland.

The physiological study and experiments produce the following conclusions:

7. In the elasmobranchs examined, neither the buccal mucous membrane nor the mucous membrane of the esophagus has any digestive activity.

8. The stomachic sac secretes pepsin and hydrochloric acid.

9. The total acidity of the stomach contents, in terms of hydrochloric acid, may reach as high as 1 per cent.

10. The physiologically active hydrochloric acid may be as strong as 0.6 per cent.

11. The gastric juice does not digest chitin.

12. The middle intestines and spiral valve have no digestive activity, but activate the pancreas.

13. The spiral valve possesses the greatest activating power.

14. The pancreas secretes trypsinogen as a rule, but may secrete trypsin.

15. The pancreas secretes amylopsin, the starch-splitting ferment, and lipase, the fat-splitting ferment.

16. The rectal gland has no digestive activity.

BIBLIOGRAPHY.

Agassiz and Vogt.—1845. Anatomie des salmones. Mémoires de la Société des Sciences Naturelles de Neuchâtel, t. III. Cited by Yung, 1899, p. 125.

Bayliss and Starling.—1903. The proteolytic activities of the pancreatic juice. Journal of Physiology, vol. XXX, p. 61.

Bellamy.—1901. On the agents concerned in the production of the triptic ferment from its zymogen. Journal of Physiology, vol. XXVII, p. 323.

Bernard.—1856. Leçons de physiologie expérimentale, etc., p. 170 et seq. Paris.

Biedermann.—1875. Untersuchungen in das Magenepithel. Sitzungsberichte d. K. Akademie der Wissenschaften, bd. 71, p. 377. Cited by Oppel, Lehrbuch der vergleichende Mikroskopie und Anatomie, bd. I, p. 36.

Bischoff.—1838. Ueber den Bau der Magenschleimhaut. Müllers Archiv für Anatomie und Physiologie, p. 503.

Blanchard.—1882. Sur les fonctions de la glande digitiforme ou superanale des Plagiostomes. Comptes rendus de l'Académie des Sciences de Paris, t. XCV, p. 1005.

1883. Sur les fonctions des appendices pyloriques. Comptes rendus de l'Académie des Sciences de Paris, t. XCVI, p. 1241.

Bondouy.—1899. Du rôle des tubes pyloriques dans la digestion. Archiv de Zoologie, 3e sér., t. 7, p. 419.

Bourchardat et Sandras.—1845. Des fonctions du pancréas et de son influence dans la digestion des féculents. Comptes rendus de l'Académie des Sciences de Paris, t. XX, p. 108.

Boyd.—1836. On the structure of the mucous membrane of the stomach. Edinburgh Medical and Surgical Journal, vol. XLVI, p. 382.

Bruno.—1899. L'excitabilité spécifique de la muqueuse du tube digestif, la bile comme agent digestif. Archives des Sciences biologiques, t. VIII, p. 27.

Cajetan.—1883. Ein Beitrag zur Lehre von der Anatomie und Physiologie des Tractus intestinalis der Fische. Inaugural Dissertation, Bonn. Cited by Yung 1899, p. 129.

Camus et Gley.—1902. À propos de l'action de la rate sur le pancréas. Comptes rendus de Société de Biologie, t. 54, p. 800.

Cattaneo.—1886. Istologia e sviluppo del tubo digerente dei pesci. Atti della Società italiana di Scienze naturali, Milano, t. XXIX. Cited by Yung, 1899, p. 131.

Chittenden and Albro.—1898. The influence of bile and bile salts on pancreatic proteolysis. American Journal of Physiology, vol. I, p. 307.

Chittenden and Cummins.—1885. Influence of bile salts and bile acids on amylolytic and proteolytic action. American Chemical Journal, vol. VII, p. 50.

CLAYPOLE.—1894. The enteron of the Cayuga Lake lamprey. Proceedings American Microscopical Society, vol. XVI, p. 125.

CORVISART.—1857. Sur une fonction peu connue du pancréas; la digestion des aliments azotés. Comptes rendus de l'Académie des Sciences, t. XLIV, p. 720.

DANILEWSKY.—1862. Ueber specifisch wirkende Körper des natürlichen und künstlichen pancreatischen Saftes. Virchow's Archiv, bd. 25, p. 267.

DECKER.—1887. Zur Physiologie des Fischdarmes. Festschrift für A. von Kölliker zur Feier seines 70. Geburtstages, p. 387. Leipzig.

DELEZENNE.—1902. Sur. la distribution et l'origine de l'entérokinase. Comptes rendus de Société de Biologie, t. 54, p. 286.

1902. Sur la presence dans les leucocytes et les ganglions lymphatiques d'une diastase favorisant la digestion triptique des matières albumenoids. Comptes rendus de Société de Biologie, t. 54, p. 283.

EBERLE.—1834. Physiologie der Verdauung. 236 p., Würzburg. Cited by Gamgee, vol. II, p. 210.

EDINGER.—1877. Ueber die Schleimhaut des Fischdarmes, nebst Bemerkungen zur Phylogenese der Drüsen des Darmrohres. Archiv für mikroskopische Anatomie, bd. XIII, p. 651.

1880. Zur Kenntnis der Drüsenzellen des Magens besonders beim Menschen. Archiv für mikroskopische Anatomie, bd. XVII, p. 193.

FERMI und REPPETTO.—1902. Beitrag zur Verbreitung der proteolytischen Enzyme im Tierreiche. Centralblatt für Bakteriologie und Parasitenkunde, bd. XXXI, p. 404.

FICK et MURISIER.—1873. Ueber das Magenferment kaltblütiger Thiere. Verhandlungen der physikalisch-medicinischen Gesellschaft in Würzburg, bd. IV, p. 120. Quoted by Yung, p. 146.

FOSTER.—1901. Lectures on the history of physiology, p. 154,-213.

FROUIN.—1902. La rate exerce-t-elle une action sur la transformation intra-pancréatique du zymogène en trypsine? Comptes rendus Société de Biologie, t. 54, p. 798.

GACHET et PACHON.—1898. Sur la secrétion de la rate. Archives de Physiologie, t. X, p. 363.

GAMGEE.—1893. Physiological chemistry, vol. II, p. 203, 210.

GEGENBAUER.—1892. Ueber Coecalanhänge am Mitteldarm der Selachier. Gegenbauer's morphologisches Jahrbuch, bd. 18, p. 180.

GREW.—1676. The comparative anatomy of stomach and guts. Printed 1681, p. 26. Quoted by Gamgee, vol. II, p. 66.

GÜNTHER.—1880. Study of fishes. Edinburgh.

HALLER.—1764. Elementa physiologiæ corporis humani, t. VI, p. 435.

HAMMARSTEN.—1901. A text-book of physiological chemistry, p. 522. Mandel.

HAUS.—1897. Beiträge zur Anatomie und Histologie des Darmkanales bei Anarrhichas lupus. Internationale Monatsschrift für Anatomie und Physiologie, bd. XIV, p. 42.

HEIDENHAIN.—1870. Untersuchungen über den Bau der Labdrüsen. Archiv für mikroskopische Anatomie, bd. VI, p. 368.

1875. Beiträge zur Kenntnisse der Pancreas. Archiv für die gesammte Physiologie, bd. X. p. 557.

1883. In Hermann's Handbuch der Physiologie, bd. 5, Absonderungsvorgänge, 4. Abschn, Bauchspeicheldrüse, p. 206.

HEKMA.—1904. Ueber die Umwandlung des Trypsinzymogen in Trypsin. Archiv für Anatomie und Physiologie, p. 343.

HERRICK.—1895. The American lobster. Appendix II, the composition of the shell and gastroliths of the lobster. Bulletin U. S. Fish Commission, vol. XV, p. 227.

HERZEN.—1901. Beiträge zur Physiologie der Verdauung. Archiv für die gesammte Physiologie, bd. LXXXIV, p. 115.

HOMBURGER.—1877. Zur Verdauung der Fische. Centralblatt für die medicinischen Wissenschaften, 15. jahrg., no. 31, p. 561.

HOME.—1814. Lectures on comparative anatomy, vol. I and II.

HOPKINS.—1890. Structure of the stomach of Amia calva. Proceedings American Society of Microscopists, 13th Annual Meeting, p. 165.

1892. On the digestive tract of some North American ganoids. Abstract in Proceedings American Association for the Advancement of Science, vol. XLI, p. 197.

1895. On the enteron of the American ganoids. Journal of Morphology, vol. XI, p. 411.

KNAUTHE.—1898. Zur Kenntnis des Stoffwechsels der Fische. Archiv für die gesammte Physiologie von Pflüger, bd. LXXIII, p. 490.

KRUKENBERG.—1877-1878. Versuche zur vergleichende Physiologie der Verdauung mit Berücksichtigung der Verhältnisse bei den Fischen. Untersuchungen aus den physiologischen Institut der Universität Heidelberg, bd. I, p. 327. Cited by Oppel, 1896, vol. I, p. 41, and Yung, p. 149.

1882. Zur Verdauung bei den Fischen. Untersuchungen aus den physiologischen Institut der Universität Heidelberg, bd. II. Cited by Oppel, 1896, bd. I, p. 41.

KÜHNE.—1867. Ueber die Verdauung der Eiweisstoffe durch den Pankreassaft. Virchow's Archiv, bd. 39, p. 130.

LEGOIUS.—1873. Recherches sur le tube de Weber et sur le pancréas des poissons osseux. Thèse Doctorat ès Sciences Naturelles. Annales des Sciences naturelles, Zoologie, t. XVII et XVIII, p. 4.

LEYDIG.—1852. Beiträge zur Anatomie und Entwicklungs-Geschichte der Rochen und Haie, p. 127. Leipzig. Cited by Yung, 1899, p. 126.

1853. Anatomisch-histologische Untersuchungen über Fische und Reptilien. Berlin. Cited by Yung, p. 126.

1853. Einige histologische Beobachtungen über den Schlammpeitzger (Cobitis fossilis). Müller's Archiv für Anatomie und Physiologie, p. 3.

1857. Lehrbuch der Histologie der Menschen und der Tiere. Frankfurt. Cited by Yung, p. 126.

LUCHHAU.—1878. Ueber die Magen und Darmverdauung bei einigen Fischen. Inaugural Dissertation, Königsberg. Cited by Yung, p. 147.

MACALLUM.—1884. Alimentary canal and pancreas of Acipenser, Amia and Lepidosteus. Journal of Anatomy and Physiology, vol. XX, p. 604.

MARTIN and WILLIAMS.—1890. A further note on the influence of bile and its constituents on pancreatic digestion. Proceedings Royal Society, vol. XLVIII, p. 160.

MAZZA.—1891. Sul tubo gastro-enterico della cepaloptera giorna. Annali della Museo civico di storia naturale di Genova, ser. 2, t. X.

MAZZA and PERUGGIA.—1894. Sulla glandola digitiforme nella Chimaera monstrosa. Atti Società ligustica de Scienze naturali, Genova, t. V, no. 25 and 26, 10 p.

MEISSNER.—1859. Verdauung der Eiweisskörper durch den pankreatischen Saft. Zeitschrift für rationelle Medizin von Henle und Pfeufer, 3. ser., bd. 7, p. 17. Cited by Gamgee, p. 217.

MENDEL and RETTGER.—1902. Experimental observations on pancreatic digestion and the spleen. American Journal of Physiology, vol. 7, p. 387.

MILNE-EDWARDS.—1860. Leçons sur la physiologie et l'anatomie comparées de l'homme et des animaux, t. VI. Paris.

MOURRUT. See Richet.

MÜLLER.—1843. Vergleichende Anatomie der Myxinoïden. Abhandlungen der K. Akademie der Wissenschaften zu Berlin, 1843, p. 117.

OPPEL.—1896, 1897, 1900, 1904. Lehrbuch der vergleichenden mikroskopsichen Anatomie der Wirbelthiere, bd. I, II, III, IV, V.

PATON.—1900. Studies of the metabolism in the dog before and after removal of the spleen. Journal of Physiology, vol. XXV, p. 443.

PARKER.—1891. Anatomy and physiology of Protopterus annectens. Proceedings Royal Society, vol. XLIX, p. 551.

PAWLOW.—1902. The work of the digestive glands. Trans. by W. H. Thompson, London, 160 p.

PILLIET.—1894. Recherches histologiques sur l'estomac des poissons osseux (Pleuronectes). Journal de l'Anatomie et de la Physiologie, t. XXX, p. 61.

RABUTEAU et PAPILLON.—1873. Observation sur quelques liquids de l'organisme des poissons. Comptes rendus de l'Académie des Sciences de Paris, t. LXXVII, p. 135.

RACHFORD and SOUTHGATE.—1895. The diastatic action of pancreatic juice. American Journal of Physiology, vol. 2, p. 483. Medical Record, vol. XLVIII, p. 878.

RATHKE.—1824. Ueber den Darmkanal der Fische. Halle, 1824.

1841. Bemerkungen über den Bau der Amphioxus lanceolatus. Königsberg, 1841. Cited by Yung, 1899, p. 125.

RÉAUMUR.—1752. Sur la digestion des oiseaux. Mémoires de l'Académie des Sciences, p. 266, 461.

RICHET.—1878. Propriétés chimiques et physiologiques du suc gastrique. Journal d'Anatomie et Physiologie, t. XIV, p. 170.

1882. De quelques faits relatifs à la digestion chez les poissons. Archives de Physiologie normale et pathologique, 14 année, 2 sér., t. X, p. 536.

1882. Des diastases chez les poissons. Comptes rendus de la Société de Biologie, t. VIII, 1884, no. I, p. 74.

RICHET et MOURRUT.—1880. De quelques faits relatifs à la digestion gastrique des poissons. Comptes rendus de l'Académie des Sciences de Paris, t. XC, p. 879.

ROLLET.—1870. Ueber die blinddarmförmigen Drüsen des Magens. Centralblatt für die medicinischen Wissenschaften, no. 21, 22, p. 325, 337. Cited by Oppel, vol. I, p. 227.

1870. Bemerkungen zur Kenntniss der Labdrüsen und der Magenschleimhaut. Untersuchungen aus dem Institut für Physiologie und Histologie in Graz, 1871, p. 143. Cited by Oppel, vol. I, p. 228.

SPALLANZANI.—1783. Expériences sur la digestion de l'homme et de différentes espèces d'animaux. Ref. in Foster 1901, History of Physiology, p. 213.

SCHEPOWALNIKOW.—1898. The physiology of succus entericus. Inaugural Dissertation at St. Petersburg. Cited by Pawlow, 1902, p. 159.

SCHIFF.—1862. Cited by Herzen in Pflüger's Archiv für Physiologie, bd. 30, p. 295, 308.

SELLIER.—1902. De l'action favorisante du suc intestinal sur la digestion pancréatique des matières albuminoides chez les poissons cartilagineux. Comptes rendus de la Société de Biologie, t. 54, p. 1405.

SIEBOLD and STANNIUS.—1854. Lehrbuch der vergleichenden Anatomie. Theil 2, by Stannius, Lehrbuch der Anatomie der Wirbelthiere, 2. aufl. 1. buch, Fische. Berlin.

STEVENS.—1777. Dissertatio physiologica inauguralis. De alimentorum concoctione. Cited by Milne-Edwards, 1859, in Leçons sur la physiologie et l'anatomie comparées, etc., t. V, p. 259.

STIRLING.—1884. On the ferments or enzymes of the digestive tract in fishes. Journal of Anatomy and Physiology, vol. XVIII, p. 426.

1885. On the chemistry and histology of the digestive organs of fishes. Second Annual Report of the Fishery Board of Scotland, app. F, no. I, p. 31.

TIEDEMANN et GMELIN.—1827. Recherches expérimentales sur la digestion considérée dans les quatre classes d'animaux vertébrés. Traduit de l'allemand par Jourdan.

TURNER.—1873. A contribution to the visceral anatomy of the Greenland shark (Læmargus borealis). Journal of Anatomy and Physiology, vol. VII, p. 237.

VALATOUR.—1861. Recherches sur les glandes gastriques et les tuniques musculaires du tube digestif dans les poissons osseux et les Bactraciens. Annales des Sciences naturelles, Zoologie, 4^{e} sér., t. XVI, p. 219.

VALENTIN.—1844. Lehrbuch der Physiologie, bd. I, p. 340. Braunschweig.

VOGT. See Agassiz.

WEBSTER and KOCH.—1903. A laboratory manual of physiological chemistry. Chicago.

WIEDERSHEIM.—1905. Grundriss der vergleichenden Anatomie der Wirbelthiere, 6. aufl., p. 422.

YUNG.—1899. Recherches sur la digestion des poissons. Archives de zoologie, 3^{e} sér., t. 7, p. 131.

ZAITSCHEK.—1904. Versuche über die Verdaulichkeit des Chitin und der Nährwert der Insecten. Pflüger's Archiv für Physiologie, bd. 104, p. 612.

FISHES OF WEST VIRGINIA

By EDMUND LEE GOLDSBOROUGH and H. WALTON CLARK

BUREAU OF FISHERIES DOCUMENT NO. 631

FISHES OF WEST VIRGINIA.[a]

By EDMUND LEE GOLDSBOROUGH and H. WALTON CLARK.

CONDITIONS IN THE STREAMS.

The particular regions visited in West Virginia were selected because of their former reputation for abundance of fishes, which abundance was now said to be decreasing. It was hoped that the cause of this decrease, if there was a decrease, might be found, and examination was made of all the streams of any importance in those parts of the state visited.

It was concluded that the aquatic life in general, and fishes in particular, had been and are now in many streams being greatly injured and in others practically destroyed by the unwise and destructive operations of the lumberman and the miner. There is no doubt that the trout have greatly diminished in numbers in certain localities and that the decrease is continuing. There is, further, no reason why this decrease can not be checked by the enactment and enforcement of protective laws and the Monongahela and upper Potomac basins become an attractive region to the angler. The water of the mountain streams is sufficiently cool for the continued residence of the trout, native and still abundant in certain localities, and efforts to protect and propagate the fish would undoubtedly produce most satisfactory and obvious results.

NORTHEASTERN WEST VIRGINIA.

The investigations were begun in 1899 at Beverly, with a route thence in a sort of irregular circle about the mountainous region, including the headwaters of the Monongahela, Potomac, and Greenbrier or their tributaries. Thus, with a comparatively small amount of journeying, it was possible to examine streams diverging into widely different regions.

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[a] Based on investigations conducted for the Bureau of Fisheries, under direction of William Perry Hay, head of the department of biology in the Washington High Schools, Washington, D. C.

Fish were found to be fairly abundant everywhere, and in the districts not affected by the lumbering or mining operations they were quite plentiful. Trout are native to all the streams and in places afford good angling. Black bass have been introduced, very probably unwisely. The bass and trout are not congenial companions, and sooner or later one or the other is driven out—usually the trout. The first plants of black bass were made in 1854 by Mr. William Shriver, of Wheeling, the fish being brought from the Ohio River in the tank of a locomotive and deposited in the canal basin at Cumberland. From the canal basin they escaped into the Potomac River, where they have greatly increased. More have since been planted at various times and places, until now the Potomac and its tributaries are well stocked.

SOUTHERN WEST VIRGINIA.

In 1900 the work was taken up in the southern part of the state. Beginning July 5, nearly two months were occupied in the examination of streams and in making extensive collections of the aquatic animals and plants. The route followed made it possible to reach and to study at several different points the tributaries of the New, Great Kanawha, Greenbrier, Big Sandy, and Guyandotte rivers, of the Ohio basin. All of these have water slightly warmer than the streams tributary to the Monongahela. The beds of most of them are rocky, but in many places there are long intervals of mud, sand, or gravel. Until within very recent years the fish life was extremely abundant, but it is now becoming more difficult each season to secure a good catch. No trout were taken in this region, though they were seen in some of the smaller streams and are said to have been abundant in the larger streams some years ago.

The agencies which have cooperated to injure and to destroy the fish are the same as those in the northern part of the state, with the additional bad effects of more active work in coal mining near the heads of the streams. Thus the fish of the Bluestone River have been greatly reduced in numbers throughout nearly the entire length of the stream by the mining operations at Pocahontas, Va. In Wyoming and McDowell counties logging and coal mining have together wrought great destruction, and streams which were formerly known far and wide as fine fishing streams are now muddy, filthy currents in which few if any fish are to be found. The railroads, in opening up new regions, have employed and brought into the country irresponsible persons who have had no hesitancy in using dynamite in order to secure a few fish, thus at the same time killing great numbers of others. Such conditions, all incidental to the industrial development of the country, could nevertheless, and should, be controlled by the state.

FISHES COLLECTED.[a]

The number of species of fishes found in the northern part of the state was 45; in the southern part but 28 were taken. Why there should be this difference is not clear, but it is probably due to the injurious effect of the lumbering and mining operations, which are more energetically pursued in this than in the northern

[a] A report on the plants collected during this investigation has been published in the Proceedings of the Biological Society of Washington, Vol. XIII, Oct. 31, 1900, p. 171–182, under the title "Some plants of West Virginia," by E. L. Morris, botanist of the party.

region. Fish are certainly less abundant here than in the northern part of the state. As already noted, no trout were secured from this region, though they were seen in some of the streams; the black bass seems to be fairly well established, but is nowhere in abundance. Eels were seen, but not taken; they were also seen in the northern part of the state in both the Potomac and Ohio basins. It is interesting to note with what persistency the eel pushes its way up from the deep-sea water—for eels spawn only in the sea—to the very headwaters of these streams, many hundreds of miles from the Gulf of Mexico or Chesapeake Bay, where they must have been hatched.

All the fish taken in the southern part of the state were from streams belonging to the Ohio basin. In the northern part they were taken from both the Ohio and Potomac basins. In the Potomac basin 14 species were found, while 46 were found in the Ohio. Two species, *Exoglossum maxillingua* and *Lepomis auritus*, were found in the Potomac, but not in the Ohio basin. The German carp has been introduced and seems to be well established in most of the streams visited in both parts of the state.

ANNOTATED LIST OF SPECIES COLLECTED IN THE OHIO BASIN.

Family LEPISOSTEIDÆ.

1. **Lepisosteus osseus** (Linnæus). *Long-nosed Gar.*
One specimen, 13.5 inches long, from Ten-mile Creek, at Lumberport.

Family SILURIDÆ.

2. **Ictalurus punctatus** (Nelson). *White Cat; Channel Cat.*
Ten-mile Creek, at Lumberport; Deckers Creek, above Morgantown; Greenbrier River, 8 miles above Hinton; Bluestone River, just above its mouth; Guyandotte River, at Baileysville.

3. **Schilbeodes exilis** (Nelson).
One specimen, 3.5 inches long, from Guyandotte River.

Family CATOSTOMIDÆ.

4. **Catostomus catostomus** (Forster). *Red Sucker.*
Harrington Creek; Right Fork of Middle Fork of Valley River, at Queens. The discovery of this species in this region is very interesting, extending the recorded range farther south and into a region where the fish was supposed not to exist.

5. **Catostomus commersonii** (Lacépède). *White Sucker.*
Cheat River, at Raines; Deckers Creek, above Morgantown; Dry Fork, at Harman; West Fork of Glady; Left-hand Fork of Middle Fork of Valley River, at Cassiday; Sand Run, 2 miles above Buckhannon; Right Fork of Middle Fork of Valley River, at Queens; Trubies Run, 7 miles above Buckhannon; Valley River, at Mingo; Bluestone River, at Abbs Valley, and at mouth of Delashmut Creek; Brush Creek, near Princeton; Delashmut Creek, at Kegley; East River, at Ingleside; Horsepen Creek, near Horsepen, Va.; Clear Fork, at Rocky Gap, Va.; War Creek, near Peeryville; Gandy Creek, at Osceola; Glady Fork, at Seneca Route Crossing.

6. **Catostomus nigricans** Le Sueur. *Hog Sucker.*
Cheat River at Cheatbridge, Ises Ferry, and Raines; Childers Run, 3 miles north of Buckhannon; Doughertys Run, near Albright; Deckers Creek, above Morgantown; Dry Fork, at Harman; Elk Creek, at Quiet Dell; West Fork of Glady; Glady Fork, at Seneca Route Crossing; Kings Run, between Beverly and Elkins; Left-hand Fork of Middle Fork of Valley River, at Cassiday; Muddy Creek, near Albright; Red Creek, at Junction with the Dry Fork of the Cheat River; Right-hand Fork at Queens; Shavers Fork of Cheat; Stonecoal Creek, between Buckhannon and Weston; Ten-mile Creek, at Lumberport;

Valley River, at Huttonsville; Barrenshe Creek, near Peeryville; Bluestone River, at Abbs Valley, and just above its mouth; Dry Fork of Tug, at Barrenshe; East River, at Ingleside; Horse Creek, southern West Virginia; Indian Creek, tributary of New River, at Greenville; Rich Creek, at Spanishburg; Clear Fork, at Rocky Gap, Va.

7. **Moxostoma anisurum** (Rafinesque). *White-nosed Sucker.*

Three specimens, 2 to 2.75 inches long, from Stonecoal Creek, between Buckhannon and Weston; 3 specimens 4.5 to 5 inches long from Ten-mile Creek, at Lumberport.

8. **Moxostoma aureolum** (Le Sueur). *Redhorse.*

Two specimens, 9 and 12 inches, Deckers Creek, above Morgantown; 4 specimens, 4 to 6 inches, Elk Creek, near Quiet Dell; 10 specimens, 2.5 to 6 inches, Hackers Creek, near Jane Lew; 4 specimens, 9 inches, Stonecoal Creek, between Buckhannon and Weston; 6 specimens, 2.5 to 5 inches, Ten-mile Creek, at Lumberport; 8 specimens, 2.25 to 6.75 inches, West Fork of Monongahela, at Weston; 7 specimens, 3 to 5 inches, Dry Fork of the Tug, at Barrenshe; 7 specimens, 4 to 6 inches, Dry Fork of Tug, at Seager; Guyandotte River, at Baileysville.

9. **Moxostoma macrolepidotum** (Le Sueur).

One specimen, 4.75 inches long, from Deckers Creek, above Morgantown.

Family CYPRINIDÆ.

10. **Campostoma anomalum** (Rafinesque). *Stone-roller.*

Elk Creek, near Quiet Dell; Greenbrier, at Durbin; Stonecoal Creek, between Buckhannon and Weston; West Fork of the Greenbrier; West Fork of the Monongahela, at Weston; Barrenshe Creek, near Peeryville; Bluestone River, just above mouth, and at mouth of Delashmut Creek; Dry Fork of Tug, at Barrenshe and at Iaeger; East River, near Ingleside; Madams Creek, across New River from Hinton; Clear Fork, at Rocky Gap, Va.

11. **Pimephales notatus** (Rafinesque). *Blunt-nosed Minnow.*

Cheat River, at Ises Ferry; Childers Run, 3 miles northeast of Buckhannon; Hackers Creek, near Jane Lew; Sand Run, 2 miles above Buckhannon; Stonecoal Creek, between Buckhannon and Weston; Ten-mile Creek, at Lumberport; Trubies Run, 7 miles above Buckhannon; West Fork of Monongahela, at Weston; Barrenshe Creek, near Peeryville; Bluestone River, just above mouth, and at mouth of Delashmut Creek, and at Abbs Valley; Delashmut Creek, at Kegley; East River, near Ingleside; Greenbrier River, 8 miles above Hinton; Horse Creek; Horsepen Creek, near Horsepen, Va.; Indian Creek, tributary of New River, near Greenville; Rich Creek, near Spanishburg; Clear Fork, at Rocky Gap; War Creek, near Peeryville; Elk Creek, near Quiet Dell.

12. **Semotilus atromaculatus** (Mitchill). *Horned-dace; Creek-chub.*

Childers Run, 3 miles northeast of Buckhannon; Kings Run, between Beverly and Elkins; Left-hand Fork of Middle Fork of Valley River, at Cassidays; Riches Run, between Beverly and Elkins; Sand Run, 2 miles above Buckhannon; Trubies Run, 7 miles above Buckhannon; Valley River, at Mingo; Big Stony Creek; Delashmut Creek; Greenbrier River, 8 miles above Hinton; Horsepen Creek; Clear Creek, Rocky Gap, Va.; Madams Creek, across New River from Hinton; War Creek near Peeryville.

13. **Semotilus bullaris** (Rafinesque). *Fallfish.*

One specimen, 2.5 inches long, from the mouth of Seneca Creek, near Harman, was the only specimen of this species secured.

14. **Leuciscus margarita** (Cope).

East Fork of the Glady River; Gandy Creek, at Osceola; Glady Fork, at Seneca Route Crossing; Kings Run, between Beverly and Elkins; Sand Run, 2 miles above Buckhannon; West Fork of the Glady; Cheat River, at Raines.

15. **Notropis whipplii** (Girard). *Silver-fin.*

Deckers Creek, above Morgantown; Elk Creek, near Quiet Dell; Sand Run, 2 miles above Buckhannon; Stonecoal Creek, between Buckhannon and Weston; Ten-mile Creek, at Lumberport; West Fork of the Monongahela, at Weston; Big Stony Creek; Bluestone River, just above mouth, and at mouth of Delashmut Creek; Indian Creek, near Greenville; Rich Creek, near Spanishburg; War Creek, near Peeryville; Greenbrier River, 8 miles above Hinton.

16. **Notropis galacturus** (Cope).

Cheat River, at Ises Ferry; Barrenshe Creek; War Creek, near Peeryville.

17. **Notropis cornutus** (Mitchill). *Shiner.*

Deckers Creek, above Morgantown; Elk Creek, near Quiet Dell; Stonecoal Creek, between Buckhannon and Weston; West Fork of Monongahela at Weston; Barrenshe Creek, near Peeryville; Dry Fork of the Tug, at Barrenshe; Horsepen Creek, near Horsepen, Va.; War Creek, near Peeryville.

18. **Notropis macdonaldi** Jordan & Jenkins.

Right-hand Fork, at Queens, 3 specimens.

19. **Notropis atherinoides** (Rafinesque).

Twenty-one specimens, 2 to 4 inches long, East River, near Ingleside.

20. **Notropis arge** (Cope).

Dry Fork, at Harman; Horsepen Creek, near Horsepen, Va.; Indian Creek, near Greenville; Clear Fork, at Rocky Gap, Va.; War Creek, near Peeryville; Dry Fork of Tug, at Barrenshe.

21. **Notropis rubrifrons** (Cope).

Cheat River at Cheatbridge, Raines and Ises Ferry; Deckers Creek, above Morgantown; Elk Creek, near Quiet Dell; West Fork of Glady; Glady Fork, at Seneca Route Crossing; Left-hand Fork of Middle Fork of Valley River, at Cassiday; Doughertys Run, near Albright; Muddy Creek, near Albright; Red Creek, at junction with Dry Fork of Cheat River; Sand Run, 2 miles above Buckhannon; Right-hand Fork, at Queens; Shavers Fork of Cheat; Valley River, at Mingo; Bluestone River, just above mouth; Horse Creek; Indian Creek, tributary of New River, near Greenville; Clear Fork, Rocky Gap, Va.

22. **Ericymba buccata** Cope.

Three specimens 2.25 to 5 inches long from Stonecoal Creek between Buckhannon and Weston and one specimen 2.25 inches long from Ten-mile Creek, at Lumberport.

23. **Phenacobius teretulus** Cope.

Three specimens, 2 to 3.5 inches long, from Bluestone River, at Abbs Valley.

24. **Rhinichthys cataractæ** (Cuvier & Valenciennes). *Long-nosed Dace.*

Cheat River, at Cheatbridge; Cheat River, at Raines; Doughertys Run, near Albright; East Fork of Glady River; West Fork of the Glady; Laurel Fork of Cheat River, near Seneca Route Crossing; Muddy Creek, near Albright; Red Creek, at the junction of the Dry Fork with the Cheat River; Right-hand Fork, at Queens; Shavers Fork of Cheat; Valley River, at Mingo; Gandy Creek, at Osceola.

25. **Rhinichthys atronasus** (Mitchill). *Black-nosed Dace.*

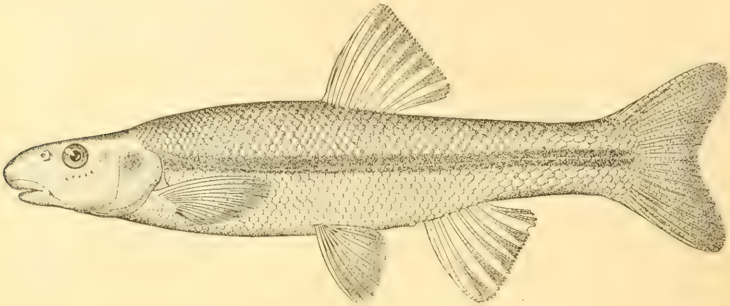
Harringtons Creek, near mouth of Youghiogheny River; Kings Run, between Beverly and Elkins; Riches Run, between Beverly and Elkins; Trubies Run, 7 miles above Buckhannon; Valley River, at Mingo; Madams Creek, across New River from Hinton; Bluestone River, at mouth of Delashmut Creek; Brush Creek, near Princeton; Delashmut Creek, at Kegley; East River, at Ingleside; War Creek, near Peeryville; West Fork of the Glady; Right-hand Fork, at Queens.

26. **Rhinichthys atronasus croceus** (Storer).

War Creek, near Peeryville, and Madams Creek, across New River from Hinton. Brush Creek, near Princeton.

27. **Rhinichthys bowersi** Goldsborough & Clark, new species.

Head 3.87 in length; depth 4.65; eye 5 in head; snout 2.6; maxillary 3; interorbital 3; preorbital 4.4; dorsal 8; anal 7; scales 10–48–7, 25 before dorsal.



Rhinichthys bowersi, new species.

Body moderately elongate, little compressed; caudal peduncle long and stout, slightly compressed, its least depth 2.1 in head; head blunt, somewhat flattened above; snout projecting, the profile above and behind eye slightly concave; mouth horizontal, inferior, its cleft not quite reaching orbit; the fleshy snout projecting beyond mouth; premaxillary not protractile, joined to the snout by a rather broad and distinct frenum; lower lip rather thin; tongue fleshy, joined to mouth; a well-developed barbel at tip of maxillary; eye somewhat anterior, high; gill-membranes broadly joined to isthmus. Teeth usually 4–4, sometimes 1, 4–4, 1; bluntly hooked and with slight grinding surface. Origin of dorsal midway between tip of snout and base of caudal, slightly posterior to origin of ventral, its longest ray 1.4 in head, base 2 in head and covering about 8 or 9 rows of scales, its margin nearly straight; caudal emarginate, lobes equal and rounded; anal similar to dorsal, its origin about 3 scales posterior to last ray of dorsal, its longest ray 1.6 in head, its base 2.5; ventrals short and rounded, 1.6 in head, reaching vent; pectoral short and broadly rounded, longest ray 1.35 in head, tip not reaching base of ventral by a distance 1.5 times greater than eye.

Scales nearly uniform on entire body, not crowded before dorsal, about as long as deep; head entirely naked; alimentary canal short, not as long as body; peritoneum dusky, with dark specks.

Color in spirits uniform olivaceous, belly somewhat lighter, fins all plain.

This species appears to be intermediate in some respects between *Rhinichthys* and *Hybopsis*. In form of mouth it resembles *Rhinichthys cataractæ*, but in general form and appearance of body it resembles *Hybopsis kentuckiensis*. The scales are too large for any known species of *Rhinichthys*, and the teeth are not those of typical *Rhinichthys*, being 1, 4–4, 1 or 4–4.

Type, no. 61576, U. S. Nat. Mus., a specimen 4.1 inches long, from the Dry Fork at Harman. W. Va., August 30; also cotype no. 5314, U. S. Bureau Fisheries, a specimen 3.8 inches long, and cotype no. 20015; Stanford University Mus., a specimen 3 inches long, both from Cheat River at Cheatbridge, July 25, 1899.

28. **Hybopsis amblops** (Rafinesque). *Silver Chub.*

West Fork of Monongahela, at Weston, and Deckers Creek, above Morgantown.

29. **Hybopsis kentuckiensis** (Rafinesque). *Horny-head. River Chub.*

Cheat River, at Cheatbridge; Cheat River, at Raines; Deckers Creek, above Morgantown; Dry Fork, at Harman; Glady Fork, at Seneca Route Crossing; Greenbrier, at Durbin; Harringtons Creek; Laurel Fork of Cheat, near Seneca Route Crossing; Left-hand Fork of Middle Fork of Valley River, at Cassiday, Little Youghiogheny, 2 miles below Oakland, Md.; Muddy Creek, near Albright; Red Creek, at junction with Dry Fork of Cheat River; Right-hand Fork, at Queens; Sand Run, 2 miles above Buckhannon; Valley River, at Mingo; West Fork of the Glady; Bluestone River, at Abbs Valley; Dry Fork of Tug, at Barrenshe; Guyandotte River, at Baileysville; Clear Fork, at Rocky Gap, Va.

Family SALMONIDÆ.

30. Salvelinus fontinalis (Mitchill). *Brook Trout.*

North Fork of Blackwater, at Cortland; Glady Fork, at Seneca Route Crossing; Cheat River, at Cheatbridge; Elk River, at Cogars Mill; Gandy Creek, at Osceola; Harringtons Creek, near mouth of Little Youghiogheny; North Fork of Blackwater, at Cortland; Blister Run, below Cheatbridge.

Family ESOCIDÆ.

31. Esox ohiensis Kirtland.

One specimen, 8 inches long, from Deckers Creek, above Morgantown.

Family ATHERINIDÆ.

32. Labidesthes sicculus (Cope). *Brook Silverside; Skipjack.*

Seven specimens, each 2 inches long, from Deckers Creek, above Morgantown; one specimen 3.25 inches long from Elk Creek, at Quiet Dell; 8 specimens 1 to 1.5 inches long from West Fork of Monongahela at Weston.

Family CENTRARCHIDÆ.

33. Ambloplites rupestris (Rafinesque). *Rock Bass.*

Beaver Creek, a tributary of Valley River, near Beverly; Chenowith Creek, between Elkins and Beverly; Cutrights Run, 5½ miles above Buckhannon; Hackers Creek, near Jane Lew; Stonecoal Creek, between Buckhannon and Weston; Ten-mile Creek, at Lumberport; Trubies Run, Tygarts Valley, near Beverly; Valley River at Huttonsville; West Fork of Monongahela, at Weston; Sand Run, 2 miles above Buckhannon; Big Stony Creek, near Bargers Spring; Greenbrier River, 8 miles above Hinton; Clear Fork at Rocky Gap, Va.

34. Apomotis cyanellus (Rafinesque). *Blue-spotted Sunfish.*

Sixteen specimens, 1 to 3 inches long, from Greenbrier River, 8 miles above Hinton; one specimen 2.75 inches long from Bluestone River, at mouth of Delashmut Creek.

35. Lepomis megalotis (Rafinesque). *Long-eared Sunfish.*

Sand Run, 2 miles above Buckhannon; Cutrights Run, 5½ miles above Buckhannon; Childers Run, 3 miles northeast of Buckhannon; Hackers Creek, near Jane Lew; Elk Creek, near Quiet Dell; Dry Fork of Tug Creek, at Barrenshe; Guyandotte River, at Baileysville.

36. Micropterus dolomieu Lacépède. *Small-mouth Black Bass.*

Chenowith Creek, between Beverly and Elkins; Valley River, at Huttonsville; Valley River, at Mingo; Peach Run, across New River from Hinton; Trubies Run, 7 miles above Buckhannon; Stonecoal Creek, between Buckhannon and Weston; Elk Creek, near Quiet Dell; Tygarts Valley River, near Beverly; Little Youghiogheny River, near Oakland; Ten-mile Creek, at Lumberport; Hackers Creek, near Jane Lew; Dry Fork, at Harman; Youghiogheny River, above mouth of Little Youghiogheny; Cheat River, at Raines; Cheat River, at Albright; Deckers Creek, above Morgantown; Left-hand Fork of Middle Fork of Valley River, at Cassiday; Muddy Creek, tributary of Cheat, near Albright; Sand Run, 2 miles above Buckhannon; West Fork of Monongahela, at Weston; Bluestone River, just above mouth; Dry Fork of the Tug, at Barrenshe and at Iaeger; Greenbrier River, 8 miles above Hinton; Guyandotte River, at Baileysville; Indian Creek, near Greenville; Rocky Gap, Va.

37. Micropterus salmoides (Lacépède). *Large-mouth Black Bass.*

Dry Fork of Tug, at Iaeger; Greenbrier River, 8 miles above Hinton.

The large-mouth black bass from Greenbrier River differ from current descriptions in having smaller scales on the cheek, the number of rows frequently being as high as 14 or 15. In this respect they approach *dolomieu*, but in other respects, such as color, size of scales on side, etc., they agree with typical *salmoides*. Some young have the conspicuous black submarginal caudal black bar, a character not found in all, and which, while common to both species, is usually more constant in *dolomieu*.

Family PERCIDÆ.

38. Percina caprodes (Rafinesque). *Log Perch.*

Elk Creek, near Quiet Dell; Stonecoal Creek, between Buckhannon and Weston; Ten-mile Creek, at Lumberport; West Fork of Monongahela, at Weston; Dry Fork of the Tug, at Barrenshe and at Ieager; Guyandotte River, at Baileysville.

39. Hadropterus macrocephalus (Cope).

Cheat River, at Raines; Shavers Fork of Cheat; Elk Creek, at Quiet Dell.

40. Hadropterus aspro (Cope & Jordan). *Black-sided Darter.*

Elk Creek, at Quiet Dell; Hackers Creek, near Jane Lew; Sand Run, 2 miles above Buckhannon; Stonecoal Creek, between Buckhannon and Weston; Ten-mile Creek, at Lumberport; West Fork of the Monongahela, at Weston; Trubies Run, 7 miles above Buckhannon.

41. Ulocentra stigmæa (Jordan). *Speck.*

Cheat River, at Ises Ferry.

42. Diplesion blennioides (Rafinesque). *Green-sided Darter.*

Doughertys Run, near Albright; Dry Fork, at Harman; Elk Creek, near Quiet Dell; Muddy Creek, near Albright; Shavers Fork of Cheat River; West Fork of the Monongahela; East River, near Ingleside; Greenbrier River, 8 miles above Hinton; Horsepen Creek, near Horsepen, Va.; Indian Creek, tributary of New River, near Greenville; Clear Fork, at Rocky Gap, Va.

43. Boleosoma nigrum (Rafinesque). *Johnny Darter.*

Elk Creek, near Quiet Dell; Hackers Creek, near Jane Lew; Sand Run, 2 miles above Buckhannon; Stonecoal Creek between Buckhannon and Weston; Ten-mile Creek, at Lumberport; Trubies Run, 7 miles above Buckhannon; West Fork of Monongahela, at Weston; Dry Fork of Tug, at Iaeger; Horsepen Creek, near Horsepen, Va.

44. Etheostoma zonale (Cope).

Obtained only in Elk Creek, near Quiet Dell, the location from which the greater number of darters taken were secured.

45. Etheostoma flabellare Rafinesque. *Fan-tailed Darter.*

Elk Creek, at Quiet Dell; Greenbrier River, near Durbin; Kings Run, between Beverly and Elkins; Left-hand Fork of Middle Fork of Valley River, at Cassiday; Riches Run, between Beverly and Elkins; Valley River, at Huttonsville and at Mingo; West Fork of Greenbrier; Big Stony Creek, near Bargers Spring; Brush Creek, near Princeton; Indian Creek, a tributary of New River, near Greenville; Madams Creek, across New River from Hinton; Rich Creek, at Spanishburg.

Family COTTIDÆ.

46. Cottus ictalops (Rafinesque). *Blob; Muffle-jaw.*

Cheat River, at Cheatbridge and at Raines; Doughertys Run, near Albright; East Fork of the Glady; West Fork of Glady; Greenbrier River, at Durbin; Harringtons Creek, near mouth of Little Youghiogheny River; Kings Run, between Beverly and Elkins; Laurel Fork of Cheat River, near Seneca Route Crossing; Left-hand Fork of Middle Fork of Valley River, at Cassiday; Muddy Creek, near Albright; Trubies Run, 7 miles above Buckhannon; Valley River, at Mingo; Right-hand Fork, at Queens; Gandy River, at Osceola; Elk River, at Cogars Mill; East River, at Ingleside.

ANNOTATED LIST OF THE SPECIES COLLECTED IN THE POTOMAC BASIN.

Family CATOSTOMIDÆ.

1. Catostomus commersonii (Lacépède). *White Sucker.*

Big Run, 1 mile above Circleville; Middle Fork of Potomac, near Crabbottom, Va.; Nydegger Run, at Gorman, Md.; Potomac River, 1 mile below Bayard, Md.; North Fork of Potomac, at mouth of Seneca.

2. Catostomus nigricans Le Sueur. *Hog Sucker.*

Big Run, 1 mile above Circleville; North Fork of the Potomac, 5 miles above Circleville; North Fork of the Potomac, at mouth of Seneca Creek.

Family CYPRINIDÆ.

3. Campostoma anomalum (Rafinesque). *Stone-roller.*
North Fork of Potomac, 5 miles south of Circleville, and at the mouth of Seneca Creek.

4. Leuciscus margarita (Cope).
North Fork of Potomac, 5 miles above Circleville.

5. Notropis cornutus (Mitchill). *Shiner.*
Big Run, 1 mile above Circleville; mouth of Seneca Creek; Middle Fork of the Potomac, near Crabbottom; North Fork of Potomac.

6. Notropis rubrifrons (Cope).
North Branch of Potomac, at mouth of Seneca Creek.

7. Rhinichthys cataractæ (Cuvier & Valenciennes). *Long-nosed Dace.*
North Fork of Potomac, 5 miles south of Circleville.

8. Rhinichthys atronasus (Mitchill). *Black-nosed Dace.*
Big Run, 1 mile above Circleville; Potomac River, 1 mile below Bayard, Md.; Franks Run, near Crabbottom, Va.; Nydegger Run, Gorman, Md.; Little Fork of the Potomac, near Crabbottom; North Fork of the Potomac, near Rockville; Potomac River, at mouth of Seneca Creek.

9. Exoglossum maxillingua (Le Sueur). *Cut-lips.*
East Branch of Potomac, at mouth of Seneca River; Seneca River; North Branch of Potomac, 5 miles south of Circleville.

Family SALMONIDÆ.

10. Salvelinus fontinalis (Mitchill). *Brook trout.*
North Fork of Potomac, 5 miles south of Circleville; North Fork of Potomac, opposite mouth of Seneca.

Family CENTRARCHIDÆ.

11. Lepomis auritus (Linnæus). *Red-breast Bream*
Only 1 specimen was obtained. This was collected at the mouth of the Seneca August 29, 1899.

12. Micropterus dolomieu Lacépède. *Small-mouth Black Bass.*
North Fork of Potomac, 5 miles south of Circleville; North Fork of the Potomac, at the mouth of Seneca Creek.

Family PERCIDÆ.

13. Etheostoma flabellare Rafinesque. *Fan-tailed Darter.*
Middle Fork of Potomac, near Crabbottom, Va.; North Fork of Potomac, 5 miles south of Circleville; Potomac River, 1 mile below Bayard, Md.; mouth of Seneca Creek; Nydegger Run, at Gorman, Md.

There is considerable variation in the color of this species. Some from Nydegger Run have the distinct side bars, but somewhat broken into above by wavy vermiculations. Others from Greenbrier River, at Durbin, have the bars distinct but not broken into vermiculations above, some black spots along the rows of scales above but not very distinct; still another from Indian Creek has the bars not so distinct, but general color darker, the black spots on each scale distinct, forming somewhat distinct longitudinal dotted lines along the side of entire body.

Family COTTIDÆ.

14. Cottus ictalops (Rafinesque). *Blob; Muffle-jaw*
Middle Fork of Potomac, near Crabbottom, Va.; Nydegger Run, near Gorman, Md.

THE PHOTOGRAPHY OF AQUATIC ANIMALS IN THEIR NATURAL ENVIRONMENT

By JACOB REIGHARD
Professor of Zoology, University of Michigan

BUREAU OF FISHERIES DOCUMENT NO. 635

PHOTOGRAPHS TAKEN WITH CAMERA SUBMERGED.

The photographs shown in this plate are reproduced without retouching from originals made on orthochromatic plates with a color screen by the use of a reflecting camera inclosed in the water-tight box described in this paper. The exposures were made in sunlight in about 4 feet of water at 11 A. M. at Tortugas, Fla., and lasted $\frac{1}{33}$ second. For further description see text, page 65.

THE PHOTOGRAPHY OF AQUATIC ANIMALS IN THEIR NATURAL ENVIRONMENT.

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INTRODUCTION.

Many things have contributed in recent years to extend the use of photography into fields of natural history not previously occupied by it. Dry plates and films have been made more rapid and, with the advent of the nonhalation and orthochromatic sorts, have been adapted to every use; with new sorts of optical glass it has been possible to construct photographic lenses of great speed; cameras and accessories have been made portable and suited to a variety of needs. As a result we find in scientific publications, as well as in more popular books and periodicals, excellent photographs of living animals and plants in their natural environment. Students and lovers of birds, field naturalists and hunters of big game have all contributed their part. Birds have been photographed on the wing and while engaged in their domestic duties, on the nest in almost inaccessible high trees, on mountain crags, and on the faces of cliffs. Mammals have been photographed in nature under a great variety of conditions. Reptiles, amphibians, insects—every variety of terrestrial animal has been pictured by the lens.

Quite in contrast has been the limited use of photography for aquatic organisms. Shufeldt (1898), Dugmore (Jordan & Evermann, 1902), Saville-Kent (1893), Fabre-Domergue (1898), have from time to time succeeded in making excellent photographs of animals in aquaria under more or less artificial conditions, but the work has been carried scarcely beyond this (see Boutan, 1893, 1898, 1898a, 1900, and Rudaux, 1908). The present paper deals rather with the photography of aquatic organisms, not merely in their native element, but in their native environment and under normal conditions. It attempts to show how they may be photographed, not by taking them from their native haunts and placing them in artificial containers, but by carrying the camera into the field. The methods described make it possible to do in some measure for aquatic animals what has been done for birds and other terrestrial forms.

PRINCIPLES OF PHOTOGRAPHY OF SUBMERGED OBJECTS.

In air the naturalist can by one method or another photograph what he sees. When he looks into clear water he may see much that it seems possible to photograph. If the surface is disturbed objects beneath it appear distorted and wavering, but if the surface is smooth they may appear as sharp and steady as though

viewed through air alone. In the latter case the photographer may set up his camera and find that he can get a perfect image on the ground glass; but if he then exposes a plate with the expectation of getting a good negative he will be sorely disappointed. Only rarely does he get any image at all of what lies beneath the water's surface. Usually the negative shows only the surface itself, and that appears as opaque as though the camera had been pointed into a lake of tar. The writer has often attempted such photographs, to find on his negative no visible impression of the fish which showed so clear on his ground glass. This is doubtless a common experience. Why is it?

Explanation will be clearer by referring to the diagrammatic figure 1, where the camera (c) is pointed toward a fish (x–y) beneath the surface (a–b) of the water. The fish is illuminated chiefly by rays of light which enter the water almost vertically. The rays of light $x\,x'$, $y\,y'$, reflected from the fish, which strike the surface of the water from below at an angle less than 48° 35′ with the vertical, emerge into the air, while at the same time they are bent from their course, as shown in the figure. Some of these rays converge to the lens, and thence diverge to form on the ground glass the image $i\ i'$. When the photographic plate is exposed these rays, with the rays from other submerged objects, form an image on it, as they do on the ground glass. Yet this image does not appear in the negative, for if the surface of the water is smooth it acts as a single great mirror which, although it permits a part of the light to penetrate, yet reflects another part, greater the more obliquely the light strikes the surface. For this reason the images of sky and trees and other distant objects are often seen mirrored on the surface of smooth water. Some of these reflected rays ($z\ z'$, $w\ w'$), after leaving the surface of the water, enter the lens of the camera and form an image. The fish is a near object and if the camera is focused upon it the image of the fish is sharp on the photographic plate. The reflected rays from the water's surface come usually from distant objects, commonly sky or clouds. When the camera is focused on the fish a sharp image

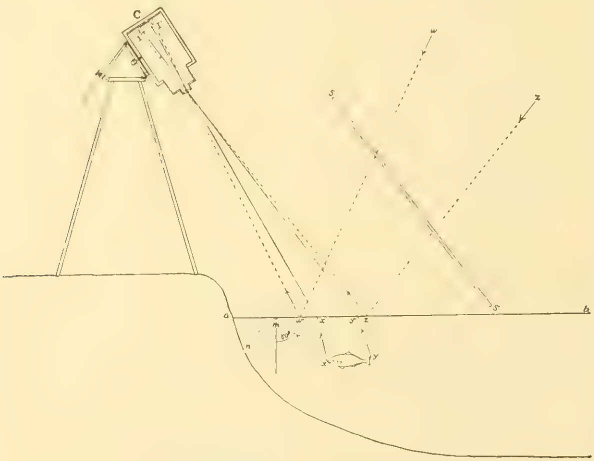

FIG. 1.—Diagram illustrating the photography of objects beneath the water by a camera above the surface. For explanation see the text.

of these distant objects is formed, not on the photographic plate, but in a plane situated somewhere between that plate and the lens, as at $I\ I'$. After forming the image at $I\ I'$ these rays again diverge and strike the photographic plate. The plate is thus flooded by light from distant objects that are wholly out of focus, so that such rays do not form a distinct image on it. This reflected light is usually brighter than the light which forms the image of the fish. It affects the plate with greater intensity, so that when the plate is developed the image of the fish is quite obscured by the general fog produced by the brighter light. There appears in the negative only a uniform dark haze, which represents the surface of the water.

If the ground glass is put in place and brought by focusing into the plane $I\ I'$, then the sharp image of distant clouds and trees is seen on it, while the image of the fish lies behind the ground glass and is no longer clearly visible. If the water is smooth, a plate exposed under these circumstances gives a sharp negative of these distant objects, but does not show the fish.

If one looks at the fish in the water from the point C it is seen clearly, because its image is focused on the retina, while the images of more distant objects mirrored in the water's surface fall in front of the retina, and the objects from which they come are therefore not seen. The observer neglects the glare of light from these distant objects, fixes his attention on the fish, and sees it. If now, while still looking toward the fish, he adjusts his eye to distant objects by relaxing the ciliary muscle, these are clearly seen mirrored in the surface of the water, while the fish is no longer sharply seen. Similarly, if a mirror is laid on the ground so as to reflect the clouds and its image is examined by focusing in a camera, it is impossible to get at the same time on the ground glass a sharp image of the clouds reflected in the mirror and of the frame of the mirror or other near object. It is only when the mirrored object lies near the surface of the water that its image can be focused on the photographic plate or retina at the same time with that of a submerged object near the surface. It nearly always happens that the light entering the camera from distant objects mirrored in the surface of the water is so much more intense than that from submerged objects that the images of the latter are quite obliterated on the photographic plate. Sometimes, on the other hand, when the camera is pointed nearly vertically into the water at an object over a light-colored bottom, the emerging light is more intense than the reflected light, and there is obtained a more or less fogged negative which shows submerged objects. This is the more apt to be the case if the photographer has the sun at his back. (See Saville-Kent, 1893.) At other times, within the limits of the reflected image (not the shadow) of a dark-colored bridge or building or of dense foliage, one may obtain a fogged negative, showing submerged objects. In this case also the partial success is due to the fact that the reflected light is less intense than that which comes from the submerged objects to be photographed. It is not often, however, that the submerged objects that one wishes to photograph are found within the reflected images of dark-colored backgrounds of sufficient size and far enough away.

The above discussion is based on the assumption that the surface of the water is smooth so that it acts as a single large mirror. If the water surface is disturbed it is broken into numerous smaller surfaces, concave, convex, or plane, and each of these acts as an independent small mirror. These form distorted images of

portions of distant objects, of natural size, magnified or reduced; and the light from them entering the camera affects the photographic plate in such a way as to obliterate the dimmer image of any object lying beneath the water. At the same time the light from the submerged object is refracted in various directions as it emerges into the air through the irregular surface of the water, so that its image as formed on the retina or ground glass is neither sharp nor steady.

From the foregoing discussion it appears that attempts to photograph submerged objects with a camera placed in air can result in only partial success, and this but rarely. Failure is due to the fact that the photograph is made through the surface of contact of two media, water and air, of very different refractive powers. If this surface is not perfectly smooth the light from an object beneath it is, upon emergence, refracted unequally at different parts of the surface and can not form a clear image on the ground glass. Whether the water is smooth or rough its surface reflects a part of the light which strikes it, and thus acts as a mirror. This reflected light makes it impossible, except under unusual conditions, to obtain photographs of submerged objects. To obtain such photographs the surface of the water must be smooth and light reflected from it must not enter the camera. Two modes of procedure suggest themselves:

(1) *The camera may remain above the surface of the water.* In that case the surface of disturbed water must be rendered smooth and the light from objects above water must be prevented from striking its surface at such angles as to enter the camera in sufficient amount to fog the plate. Methods devised by the writer for accomplishing these two results are taken up and illustrated in the following section.

(2) *The camera may be placed beneath the surface of the water*, so that this surface does not intervene between the camera and the object to be photographed. The light which enters the camera is therefore neither refracted nor reflected at this surface, and images may be obtained on the ground glass as clear and steady as though viewed through air alone. Methods of the writer and others for accomplishing this are described and illustrated in the final section of this paper.

A NEW METHOD OF PHOTOGRAPHING SUBMERGED OBJECTS WITH THE CAMERA ABOVE THE SURFACE.

It was pointed out in the preceding section that if the camera with which submerged objects are to be photographed is to remain above the surface of the water means must be found (1) greatly to reduce the amount of reflected light entering the camera from the surface of the water, and (2) to render the surface of the water smooth. We may consider first the case in which the surface of the water is smooth, so that it is necessary merely to minimize surface reflection.

The method to be described is best adapted to objects in water not more than 2 or 3 feet deep, and the best results are obtained when the water is less than a foot in depth. Any type of camera may be used, but since the objects to be photographed are necessarily quite near the camera they are out of focus with a fixed-focus camera, so that the best results are obtained when the camera is one that can be focused. Since the objects to be photographed are usually in motion, and since the surface of the water may at any time be roughened by a puff of wind,

it is best to use a lens suitable for instantaneous exposure—a lens of a speed not less than f 8. The operator should first select the point from which the picture is to be taken. He should, of course, have the sun at his back or to one side. If possible he should stand on the bank or on some fixed support which extends above the surface of the water. From such a position the camera is at a greater height and may usually be directed at the surface of the water at an angle of about 45° or less from a vertical extending upward from this surface. Rays of light from submerged objects striking the surface of the water from below at an angle of 48° 35′ from a vertical drawn downward (or at a less angle), emerge. They may thus, after refraction, reach the camera as indicated by the line $x\,x'\,i'$ in figure 1. Rays which strike the surface of the water from below at an angle of more than 48° 35′ with the vertical are, on the other hand, reflected at the surface so that they do not emerge and enter the camera but pass down again into the water, as indicated by the line $x\ m\ n$ in figure 1.

FIG. 2.—Tripod top by means of which the camera may be inclined at any angle. For explanation see the text.

If the operator is unable to find a fixed emergent support for the camera he may make the exposure while standing in the water. The camera may then be held in the hand or may be supported on a tripod which rests on the bottom. As the legs of the tripod are likely to sink into the bottom they should be extended to their full length. Where the bottom is firm an elevated position may be obtained for the camera by using a tripod with legs some 10 feet long, such as dealers sell for use in making pictures of large groups. In such tripods one leg forms a ladder by which the camera may be reached.

The tripod top should consist of two rectangular wooden pieces, as shown in figure 2 and in section in figure 1. To the lower piece, which has a large circular opening at its center, the legs are attached. The camera is fastened by the tripod screw to the upper piece in such a way that one of the legs projects directly backward instead of directly forward, as is usual. The two pieces are hinged together at one edge, so that they may lie parallel to one another or may be separated like the covers of a book until the upper piece forms an angle of 90° with the lower. A rod is pivoted by one end to the upper piece at the middle of its free edge, so that it swings freely in the vertical plane. This rod passes through a perforated metal block pivoted by one end at the middle of the free edge of the lower piece so as to swing freely

in a plane vertical to that piece. When the two pieces are separated by moving the upper one on the hinge which connects them the rod slips through the opening in the block and may be firmly clamped at any point in its length by means of a set screw. Thus the upper piece may be held firmly at any angle to the lower piece from 0° to 90°, and the camera may be pointed at the water at any desired angle. The position in which the legs of the tripod are attached permits the camera to be pointed directly downward in the space between the two front legs, whereas if the legs were attached in the usual manner with one leg in front it would be impossible to bring the camera into the vertical position. Tripods of this type are to be found in the market or may be made from an ordinary tripod by any mechanic.

When the operator has placed his camera and roughly adjusted it, he should set up a screen to cut off the light reflected from the surface of the water into the camera. Any piece of dark fabric, a blanket, shawl, or for small objects even a coat, may be used. It may be supported by hand or tied to poles stuck in the bottom. The writer carries into the field a screen made by sewing together pieces of black calico to form a sheet either 6 or 9 feet square. To three of the edges of this, at intervals of about a foot, are sewn pieces of tape each about a foot long and attached at its middle so as to leave 6 inches projecting on each side. One piece of tape should be attached to each corner of the screen. Two poles are cut of sufficient length to project 6 to 10 feet above the water when firmly set in the bottom. The poles are sharpened at one end, and beginning at the unsharpened end the square of calico is tied to them by the opposite edges by means of the tapes. The third side to which tapes are attached is the upper, between the unsharpened ends of the poles. The poles are now thrust into the bottom on that side of the camera opposite the object to be photographed and so that they slant toward the camera. The screen (*s s′*, fig. 1) is thus stretched upward from the surface of the water in a slanting position, so that its upper edge is nearer the camera than its lower. If the two poles are pulled together by the weight of the cloth or the action of the wind so that the screen sags, a third pole tied between their upper ends will keep them apart, while the tapes on the upper edge of the screen will serve to attach it to the cross-pole.

If the operator now returns to the camera he will see the screen mirrored in the surface of the water. The object to be photographed should fall within the limits of this mirrored image as seen from the camera.[a] If it does not, the screen or the camera must be shifted until it does. The operator will see also the shadow of the screen. This should *not* fall on the object to be photographed. The screen should, if possible, be adjusted by slanting it or by moving one of the poles so that the sun strikes it nearly edgewise, but yet does not strike that face of it which is toward the camera. If this adjustment is properly made the shadow of the screen is a very narrow band, which lies beneath the screen and a little nearer the camera than its lower edge. The full sunlight then falls on the object while the rays from

[a] Saville-Kent (1893) apparently utilized this principle when photographing with a vertical camera on the Australian barrier reefs, but Rudaux (1908) stated the principle explicitly as applied in photographing in natural waters with a vertical camera objects within the reflected image of the tripod top. Neither recognized the broad application of the principle here described.

distant objects which would otherwise be reflected into the camera from the surface of the water are cut off. If the sunlight is permitted to fall on that face of the screen which is toward the camera, it is reflected from the screen to the surface of the water and thence into the camera. A picture taken under these conditions may show, besides the object under the water, also the screen itself, although this image of the screen is usually so faint that it does not interfere with the use of the picture for scientific purposes.

When the screen has been properly set the operator has merely to adjust the camera and make the exposure in the customary way. If the subjects are fish they will usually have been frightened away, but if the fish are engaged in nest building or in some other occupation that attracts them to a particular spot, they will, in most cases, return after a time varying from five minutes to an hour. The operator has merely to remain quiet until this happens. The photographer may focus his camera on the spot to which the fish is likely to return and then withdraw and operate the camera from a distance by pulling a string or pressing a bulb when the fish returns. The method is of most use in securing photographs of the nests and habitats of fish in shallow water, yet the writer has succeeded by means of it in making some satisfactory photographs of fish on the nest.

The result of using the screen is shown in figure 1 of plate III, which is a photograph of the nest of a small-mouthed black bass. The screen in this case was stretched on a frame and was held by hand. Within the limits of the reflection of the screen in the water's surface the bottom may be seen clearly. At the center are the larger stones which form the bottom of the nest, and these show sharply the details of their markings. Outside the limits of the reflection of the screen the bottom is not clearly visible; its image has been obscured on the sensitive plate by the bright light reflected from the surface of the water. The sun struck the back of the screen from the left, as is shown by the shadow which lies close to the screen. Within the limits of this shadow the plate was underexposed and details of the bottom are not visible. With a longer exposure as good a negative could have been made of what lay in the shadow.

If the surface of the water is not smooth it may be made so by a water glass, which may be constructed as follows (fig. 1, pl. IV): A square frame is made of heavy galvanized iron, and measures 3½ inches deep and 12 inches on each side within. One of its edges (the top) is turned outward three-fourths of an inch and then downward one-half inch to form a lip. This stiffens the frame and tends to prevent water from slopping into it. The lower edge of the frame is turned outward about half an inch to form a flat surface, against which the glass, 13 inches square, is bedded in aquarium cement. After the glass is in position four trough-shaped pieces are soldered to the sides of the frame and to one another in the manner shown in the figure. The free edges of these pieces project inward beneath the lower surface of the glass and support it. Before the pieces are soldered into place cement is placed between them and the lower face of the glass. The whole border of the glass is thus bedded in cement on both surfaces and at the edge. To protect the glass when not in use a flat cover is provided, which fits against its lower face. Such a water glass may

be floated over the object to be photographed and a screen set up independently of it, or the screen may be attached to the glass itself. For the latter purpose a piece of half-inch band iron may be bent to form the three sides of a rectangle, 8 by 12 inches, and this may be riveted as a bail (fig. 1, pl. IV) to the inside of the frame, about 8 inches from one side. The bail should turn on the rivets so that it may be depressed into the frame when not in use. A screen may be formed by raising the bail and tying a piece of black cloth from it to the opposite side of the frame. In shallow, running water it is desirable to support the water glass from the bottom in order that it may not sink so much as to displace or distort the object to be photographed. It may be supported on four iron rods which run through metal sleeves soldered to the four corners of the frame. The rods may be fixed in any position in the sleeves by means of set screws, and may project upward far enough to support the upper edge of the screen. A water glass arranged in this way is shown in figure 2, plate IV, where it is being used for observation, but with the same glass photographs were obtained of lamprey eels in the act of spawning. Such a photograph is reproduced in figure 2, plate III, where the rough surface of the running water made the use of the water glass imperative. The white bands across the picture are the edges of the frame of the water glass. Outside this frame at the right, where the water is rough, little is visible. The screen was almost as necessary as the water glass.

The writer has used water glasses of this type varying in size from 1 to 3 feet square. Those of 1 foot square are of use chiefly for observation, and even for this purpose the screen is a valuable addition. Those of 3 feet square are so unwieldy that a vehicle of some sort is needed to carry them. The size most suitable for field photography is 2 feet square, since this may be transported by hand.

The method described in this section is suited only to shallow water, where the camera may be supported from a firm substratum. In deeper water the unsteadiness of the boat would interfere with the manipulation of a water glass or a screen. It might be possible, however, to construct a boat of which the water glass and the screen should form constituent parts. The method described permits only of views at angles of from about 48° to 90° to the water's surface. Since it is not practicable to place the camera far above the water at these angles or to use screens of very large size, the pictures that may be taken are of near objects and the field covered by them is of limited extent. If a water glass is used, the camera must be near it and the field is limited by its frame. The method is, however, the only one known to the writer for certain kinds of work. Often, as in the case of the bass nest shown in figure 3, the objects to be photographed are in water so shallow that the camera must be placed above its surface; there is not room for it beneath. Often, though the object may be in deeper water, it is so surrounded by vegetation that it can not be seen from a little distance except from above. It must then be photographed from above. Where the water is both shallow and disturbed, as in small streams, the use of a water glass is essential. There are therefore many objects about the borders of lakes and in streams to which this method may be applied when no other known method is available. On the other hand, wherever it is possible to use a submerged camera, results may be obtained with greater ease and certainty in the manner shown in the section which follows.

PREVIOUS ATTEMPTS TO PHOTOGRAPH SUBMERGED OBJECTS BY MEANS OF A SUBMERGED CAMERA.

Photography by means of a submerged camera was first attempted by Dr. L. Boutan, of Paris, at the seaside laboratory of Roscoff, in 1893. His work was continued through the seasons of 1895, 1896, 1897, and 1898, and the results have been published in four communications (Boutan, 1893, 1898, 1898a, 1900). Boutan's apparatus was used wholly in the sea, and he has given to his method the title "la photographie sous-marine." I shall use instead the broader term subaquatic photography, as indicating the wider application of the method to both fresh and salt water.

Boutan made use of three forms of apparatus, which may be designated as his first (1893), second (1896), and third (1898) apparatus. Each of these will be briefly considered.

He was led to take up subaquatic photography by his study of the development of the mollusk *Haliotis*. Finding it impossible to rear the larvæ of this form in aquaria and failing to collect them in their natural environment by the usual methods, he decided to search for them by descending in a diver's suit. He was struck by the beauty and interest of the submarine landscape and of its inhabitants. He found it impossible to bring his experiences vividly before others by mere verbal description and equally impossible, while inclosed in the cumbersome garments of the diver, to make drawings, or even sketches, of what he saw. He was thus led to try photography. He appears to have made no attempt to operate with a camera placed above the water, for, as he says, "when the surface of the liquid is absolutely quiet the rays of light coming from submerged objects enter the objective placed in air at the same time with the rays reflected by this mirroring surface and that suffices to destroy all clearness in the images." He objected to this method for the further reason that it could result in giving only a plan or bird's-eye view similar to that which is obtained when landscapes are photographed from the elevated car of a balloon. He therefore decided to construct an apparatus that could be used under water. It seemed to him possible to proceed on either one of two principles: (1) "To have made an objective that could be immersed directly in water." (2) "To have built a tight box in the interior of which the ordinary objective could be placed protected from salt water." In his first and third forms of apparatus Boutan made use of the second principle. In his second attempt he made use, without success, of an objective immersed in water.

BOUTAN'S FIRST APPARATUS (1893).

In this apparatus Boutan made use of a detective camera of fixed focus, an instrument intended to make instantaneous pictures at all distances beyond 3 or 4 meters without focusing. This camera was of the box form usual in detective cameras. It was provided at the front with an opening for the lens and above this with two openings for the finder. At the front there was on one side a lever or button which controlled the shutter and at the back a rod by the movement of which it was possible, without opening the box, to change the plates, a number of which were carried in the magazine of the camera.

This camera was inclosed in a copper box (fig. 3). The top of the box was open and was stiffened by a projecting rim against which a cover could be clamped by means of eight metal screw-clamps. The joint between the rim of the box and the cover was made water-tight by means of a heavy rubber gasket let into rectangular grooves in both the rim and the cover. The box was intended to be used at considerable depths. The pressure of the water on its outside would at 10 meters depth be one atmosphere plus the pressure exerted by a column of water 10 meters high, while the pressure on the inside of the box would be what it was when the box was closed at the surface, one atmosphere. Under these circumstances there was serious danger that the excess pressure on the outside of the box would force the water through between the rim and the cover in spite of the most careful construction of the joint between the two. To overcome this difficulty, the cover of the box was provided at its center with an opening which extended upward into a metal tube, and to this tube there was attached an air-filled rubber bag of about 3 liters capacity. When the box was submerged the pressure of the water on the bag was communicated to the air within, so that the pressure on the inner surface of the box was exactly equal at all depths to that on its outer surface. Thus there was no excess pressure on the outer surface of the box to force the water inward against a less pressure within.

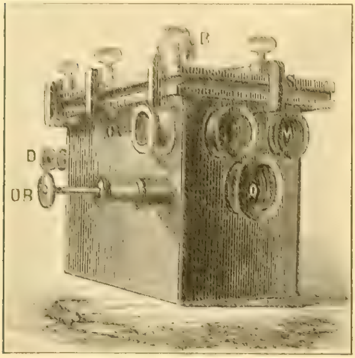

FIG. 3. Boutan's first apparatus. Box used in 1893 for inclosing a detective camera to be used under water. B, rubber balloon filled with air; D, handle at the back for operating the magazine plate holder; O, opening corresponding to the lens; OB, handle at the side controlling the shutter; V, front finder; OV, lateral finder. (Copy of fig. 1 in Boutan, 1893.)

The front of the box was provided with three circular openings closed by plates of glass with parallel surfaces. The one at the center was opposite the lens; the two above it were for the finder. A similar opening on one side was also closed by a glass plate and served for the finder. On the same side was a rod which terminated at its outer end in a milled head. Its inner end extended, through a stuffing box which was water-tight, to the interior of the box. By pulling the rod in and out the shutter could be operated. A similar rod at the back of the box could be slid in and out and served to change the plates. When in use the camera was supported on a heavy tripod of iron.

The apparatus was used either while the operator remained in shallow water with his head and shoulders above the surface or when he had descended to the bottom in a diver's suit. When working in shallow water, he put on the diver's suit in order to be protected from the water, but omitted the casque covering the head and the heavy weight ordinarily attached to the back and front of the suit. Thus arrayed, he placed the tripod in position and attached the camera to it. In

order to bring the camera to bear on the object to be photographed, it was then necessary to provide a way to determine when the image of the object appeared in the desired position in the finder. This was accomplished by using a metal tube open at both ends, one end of the tube being placed over the ground glass of the finder and the other, which extended above the water, being applied to the eye. The tube excluded the light from the space between the eye of the observer and the finder, while at the same time the water within it was protected from agitation. By this means it was possible to see clearly the image on the ground glass of the finder. It was necessary merely to manipulate the handle controlling the shutter in order to begin and end the exposure. The plate could then be changed by manipulating the rod at the back of the box and another exposure made at once without taking the camera from the water. Where it was possible to operate near shore, it was unnecessary for the operator to put on the diver's suit or to enter the water. He could set the camera in place from the shore and adjust it or make the exposure while lying upon the bank. Boutan, indeed, made satisfactory photographs of fixed animals in aquaria by immersing this apparatus in an indoor aquarium and operating it by means of a string. By using a very small diaphragm he was able to get clear images of objects at a distance of 15 centimeters from the lens, but this required an exposure of three minutes. He obtained photographs of fish and other mobile forms in the same manner by inclosing the animal to be photographed in a glass globe, which was then immersed in the aquarium at a suitable distance from the lens. The globe served to restrict the movements of the animal. When working in shallow water, he found that the algæ which appear everywhere in the submarine landscape were in constant motion whenever there was any movement of the water. It was therefore necessary to restrict operations to those days on which it was perfectly calm.

In order to obtain photographs at depths at which it was impossible to wade Boutan made use of the diver's outfit. He describes the outfit in detail and the method of using it in a very interesting section of his paper of 1898. The method of procedure was briefly as follows: The boat containing the apparatus to be used (diver's suit, air pumps, and photographic apparatus) was first firmly anchored at the spot selected and held in place by means of cables stretched to the rocks on shore. The photographer then put on the diver's suit and descended to the point selected as the center of operations. He first signaled to an assistant to let down the photographic apparatus, which consisted of the tripod, the box containing the camera, and a weight intended to steady the apparatus. He then sought out the view to be taken and set up the apparatus at his leisure. This accomplished, he opened the shutter of the camera and signaled to the assistant that the exposure was begun. Since it was impossible to use a watch while under water it was necessary that the assistant in the boat above should time the exposure. At the expiration of the time agreed upon the assistant signaled and the photographer closed the shutter. When the weather was good and the sun shining an exposure of ten minutes was necessary with a small diaphragm at a depth of 5 meters. Boutan estimated that at a depth of 10 meters this exposure would need to be more than doubled.

BOUTAN'S SECOND APPARATUS (1896).

This apparatus (fig. 4) consisted of a metal camera, not inclosed in a box, but intended to be immersed directly in sea water. The sea water could enter and fill the interior of the camera so that it bathed both the front and back faces of the lens as well as the plates. The latter were contained in a holder which could be attached to the camera after it was submerged. Thus the plates could be changed under water without any risk of fogging them. Sea water was found to have little effect on the plates unless its action was prolonged, and this effect could be wholly prevented by using plates that had been varnished.

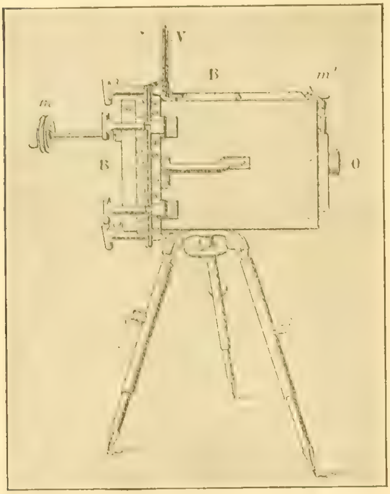

FIG. 4.—Boutan's second apparatus. B, camera box into which the water could penetrate freely; *m*, handle controlling the plate holder; *m'*, handle controlling the shutter; O, objective; V, sight. (Copy of fig. 2 in Boutan, 1898.)

The lens used with this apparatus was one intended for use in air, and it was found that good results could not be obtained with it when immersed in water. The success of such an apparatus as this must depend on having a lens especially ground for use under water. No lens of this sort existed and to have one calculated and made would have been expensive. For this reason and for others which he mentions Boutan abandoned this apparatus after trying it for a single season. He says, "The principle is certainly good, and, in spite of the failure that I have made in the application of it, the future of submarine photographic apparatus may lie there."

BOUTAN'S THIRD APPARATUS (1898).

As a result of the failure of his second, Boutan adopted a third apparatus, which was in principle a return to the first. This third apparatus, designed for instantaneous work, consisted of a heavy metal box, shown at the center in figure 5. To it are attached four adjustable legs. The box, which is water tight, contains the objective and the plates. It is itself the camera and does not therefore contain within it a camera, to be lifted out and put back. The lens is a Darlot symmetrical-anastigmatic of excellent quality. At the front is an opening (O) closed by a plate of glass, through which the light enters the lens. There are no finders and consequently no openings closed by glass plates, with the exception of that for the lens. At the top, in front, is a handle by means of which the shutter may be operated. About the center of the box is clamped a band-iron frame with a ring at the top by means of which the box may be attached to a rope for lifting it in and out of the boat. At the back is a cover which may be fastened by means

of screws against a rubber packing on the end of the box, so that the joint between cover and box is made water tight. The rubber bag used in the first apparatus seems to have been found unnecessary and is at any rate omitted. At the back of the cover there projects a handle (M) by the manipulation of which the plates may be changed. On the top at V is a sight by means of which the camera may be directed at the desired object. Within the box at the back is a magazine plate holder for six plates. This is represented at the left at C H in figure 9. It is so arranged that when a plate has been exposed it may be made to fall forward by turning the handle shown at M in the central figure. A second plate is at the same time pushed into place by springs. When this has been exposed a second turn of the handle allows the plate to fall and a third plate comes into place. Six plates may thus be exposed without opening the box. On each side of the plate holder are two cleats (*gl*). These glide upon two rails on the inside of the box, one on either side, so that the plate holder may be moved back and forth on the rails away from the lens or toward it. By means of a set screw the plate holder may be firmly clamped at any point on the rail. The camera is focused by means of this movement of the plate holder. To prevent reflection of light from the lower side of the surface film of the water into the camera there is provided a semicylindrical shade shown at A B on the right in figure 5. It may be attached to the front of the box above the lens by the arrangement shown at X.

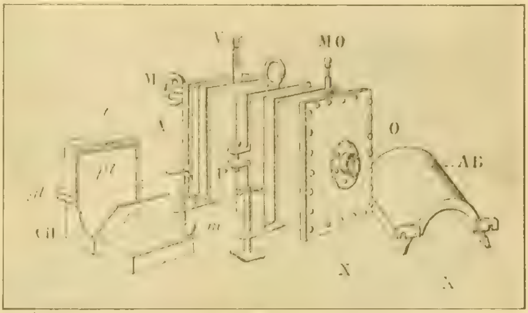

FIG. 5.—Boutan's third apparatus (1898). A, metal camera box; M, handle controlling the changing of plates; MO, handle controlling the shutter; O, opening for the lens; P, feet for supporting the apparatus; V, sight; X, points of attachment of the hood AB; CH, magazine holder for six plates; *gl*, cleats by means of which the holder glides on a rail inside the box; *pl*, plates; *t*, pin which holds the front plate in place. (Copy of fig. 3 in Boutan, 1898.)

It is not possible to focus after the box has been closed in order to immerse it. Consequently one of the rails upon which the plate holder moves must be provided with a scale. The divisions on this scale correspond to different distances between the lens and the object to be photographed. When the plate holder is set at a certain division of the scale the camera is in focus for objects at a distance of 4 meters; when set at another division for objects at 2 meters. It is therefore necessary to determine before the camera box is closed at what distance the object is to be photographed and to focus by setting the plate holder at the corresponding division on the scale. While the box is immersed this focus cannot be changed. The divisions to be marked on this scale were obtained by focusing on submerged objects while the front of the camera was also submerged. This necessitated the use of special devices, which need not be described here.

This apparatus, which used plates 18 by 24 cm. (approximately 7 by 9 inches), was so heavy that it required three men to handle it easily in air. On shipboard it was handled by a tackle and swinging boom. It was first lowered into the hold, which could be closed light tight. There the plates were put into the plate holder and this was set at the division of the scale previously decided upon. The box was then closed water-tight by screwing the cover in place. To remove the moisture from the air within the box and thus prevent its condensation on the lens and other parts within, a wide-mouthed bottle containing quick lime was kept in the box during the intervals when it was not immersed. The apparatus was then hoisted from the hold, swung outboard and lowered to the operator, who had meantime descended in the diving suit and selected the point at which the photograph should be made. It was not very difficult for the operator to handle the apparatus when it was sub-

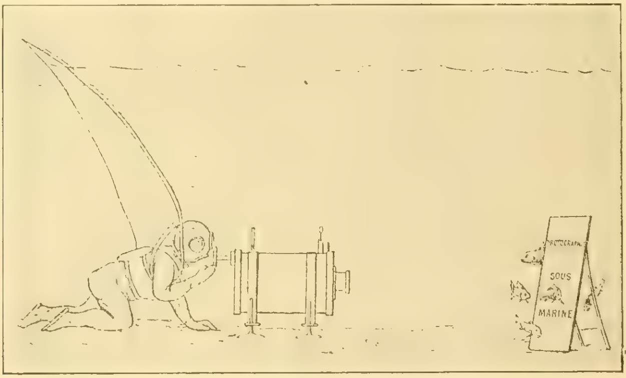

FIG. 6.—Showing Boutan's method of obtaining instantaneous photographs of fish with his third apparatus. (Copy of fig. 7 in Boutan, 1898.)

merged, since it was then buoyed up by the water. It was found easier to move it about when it was suspended by means of a rope to a cask floating at the surface.

The method of using the camera for photographing fish is shown in figure 6. The camera, previously set for objects at a distance of 2.5 meters, was placed on a sand bottom at a depth of 3 meters. Here it was either allowed to rest on the bottom on the legs attached to it or was supported above the bottom on a heavy, four-legged iron frame. The camera rested on a platform within this frame and the platform might be so adjusted that the camera could be set at various heights and pointed at various angles up or down. At a distance of 2.8 meters from it was set up obliquely a large white screen of painted canvas stretched on an iron frame provided with feet. This screen served as a background for the fish. To attract the fish the operator then placed in front of the screen at a distance of about two meters a bait of crushed sea-urchins and annelids. He then pointed the camera by means of the sight on top and waited until the fish, attracted by the bait, were in such a position as to be in focus, when by means of the handle at the

front he made the exposure. The plate was then changed and several exposures made in succession. The screen was useful as affording a contrasting background but was not considered necessary, since very clear negatives were obtained of fish viewed against the sand or ooze bottom. One of the photographs of fish taken against a screen background is reproduced by heliogravure in Boutan's memoir of 1898. Though the fish were in motion, the outlines of most of them appear sharp against the screen, evidence that the picture was instantaneous. The fish are, however, unfortunately almost wholly lacking in detail. The time of the exposure is not stated, but it was clearly too short to give detail in the shadows.

In figure 7 is shown a method adopted by Boutan for operating the camera from a boat by means of a string. In this case the apparatus was first placed in

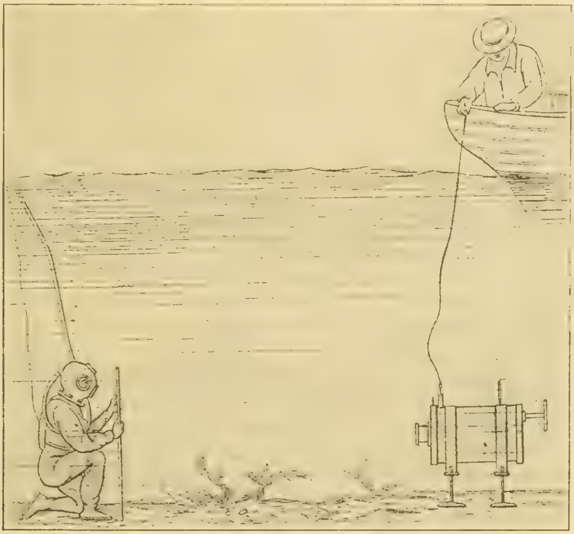

Fig. 7.—Showing Boutan's method of operating his third apparatus from a boat by means of a string. A diver is being photographed. (Copy of fig. 8 in Boutan, 1898.)

position by the diver, who then withdrew to the distance for which the camera was focused. The operator, who could observe the procedure from the boat, then pulled the string. The resulting picture, which is reproduced in Boutan (1898), is excellent. Subsequently exposures were made from the surface by using a shutter controlled by an electro-magnet.

BOUTAN'S METHODS OF ARTIFICIAL ILLUMINATION.

Besides his camera, Boutan (1893) describes an apparatus for using a magnesium flash-light beneath the surface of the water. He succeeded subsequently in taking good instantaneous pictures at a depth of 3 meters without artificial

light, and estimated that in good weather it would be possible to do this at depths of 7 or 8 meters.

Although his flash-light apparatus proved to be unnecessary in shallow water and was subsequently abandoned as cumbersome and dangerous, it merits a word of description. His figure of it is reproduced in figure 8. In its final form it consisted of a cask of about 200 liters capacity closed at both ends, but with the lower end perforated by holes to permit the entrance of sea water. A bell jar of 5 or 6 liters capacity is held tightly against the upper end of the cask by means of the adjustable frame shown in the figure. The cavity of the jar communicates freely through many openings with that of the cask, and both are filled with air. Within the bell jar is an alcohol lamp, and at the side of this is a metal reservoir (not shown in the figure), covered with asbestos and filled with magnesium powder. One end of a metal tube opens opposite the middle of the flame of the alcohol lamp (shown lighted in the figure) and communicates freely with the reservoir above. The other end of the tube extends into the cask, and is there connected to a rubber tube which extends through the side of the cask (at *C* in fig. 8) and ends in a large rubber bulb. To use the apparatus, the reservoir is filled with magnesium powder and the alcohol lamp lighted, then the bell jar is fastened in place and the cask, heavily weighted at the bottom, is lowered into the water and set wherever needed. The air in the bell jar and cask is enough to keep the alcohol lamp burning for some time. To produce the flash it is merely necessary to press the bulb, when the magnesium powder, which has fallen from the reservoir into the tube, is blown against the flame from the end of the tube and ignited. This operation may be repeated as long as the lamp remains burning and the reservoir contains magnesium. It is of course necessary to operate the shutter of the camera simultaneously with the flash.

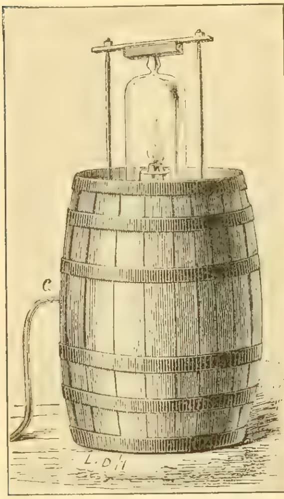

FIG. 8.—Boutan's apparatus for using a magnesium flash-light under water. The reservoir for the magnesium powder, the rubber bulb, and the weights used to steady the apparatus are not shown in the figure. (Copy of fig. 3 in Boutan, 1893.)

Boutan (1900) describes and illustrates another illuminating apparatus which consists of two powerful arc lamps inclosed in water-tight jackets of heavy metal, designed to withstand the pressure of the water at a depth of 50 meters or more. Each jacket was pierced by an opening into which was fitted a condensing lens, by which the emerging light was concentrated upon the object to be photographed. The two lamps were rigidly attached to the camera support and were supplied, through a cable, with current from storage batteries on board the boat. The same cable carried also an insulated wire through which an electro-magnet actuating the shutter of the camera could be controlled. The camera with lamps attached was lowered into the water. When the camera was on the bottom the lamp circuit was closed by means of a switch on board the boat, and when it was

seen that the lamps were working, the shutter was operated from the boat. In this way good photographs of gorgonias were obtained at night at a depth of 6 meters, with an exposure of five seconds. It is not necessary that the diver should descend to place the lamp in position. The same apparatus was worked successfully at a depth of 50 meters, in this case the apparatus not being allowed to rest on the bottom, but being held suspended from a cable at some distance from the bottom. The object photographed was a canvas screen rigidly attached by rods to the camera support at such a distance from the lens as to be sharply focused. When the apparatus was brought to the surface it was found that one of the lamps had failed to withstand the pressure so that its jacket was filled with water. With lamps and camera constructed to withstand the pressure at great depths, Boutan believes that an apparatus of this sort may be used at depths to which light does not penetrate. The apparatus may of course be used by a diver at depths of 40 meters or less, and the camera may then be directed at any desired object; but at greater depths a diver can not work, and the apparatus must then of course be let down at random, to photograph only what chances to be in the range of its lens.

Boutan's work has the great merit of having demonstrated that it is possible at a depth of 3 meters to obtain good instantaneous pictures by the light of the sun and without the use of artificial light. He showed further that his apparatus with electric illumination could be immersed and operated from outside the water at depths as great as 50 meters. For work at great depths or by artificial light no better apparatus is known. The faults of it, for work in shallow water or at any depth to which a diver can descend, are (1) its great bulk and weight, and (2) the fact that it can not be focused under water. It can not be carried about freely, and for use it must be set on the bottom at a known distance from the object to be photographed and must then be sighted at that object. It is unfortunate that for work in shallow water Boutan did not make use of the principle of the twin camera or the reflecting camera, for by using either of these devices he could have made an apparatus that was portable and that could have been focused under water. He could thus have carried his camera about as one carries detective cameras and could have photographed submarine objects either while wading with his head above water or in moderate depths while on the bottom in a diver's suit.

BRISTOL'S SUBAQUATIC CAMERA.

That such a method is feasible and that it may yield better results than those obtained by Boutan was suspected as early as 1898 by Prof. C. L. Bristol, who immediately began work on a submarine photographic apparatus. Nothing has as yet been published concerning this apparatus, and the details of its construction are quite unknown to me. Professor Bristol kindly permits me, however, to make the following quotation from a letter to me on the subject: "From the first I have used a water-tight camera capable of submersion in from 10 to 15 fathoms, mounted on a tripod with a universal motion, arranged so as to show the picture on the ground glass as well as to focus the lens and make the exposure. Moreover, a magazine attachment permits me to carry down several plates and to change them after each exposure while under water. After several seasons' efforts the apparatus is now very efficient and has produced excellent results. I am not yet ready to publish a detailed account."

A NEW SUBAQUATIC APPARATUS.

When a camera for subaquatic use is made after the ordinary type the box must be securely closed before submerging it in order to protect the lens and the plates from the action of the water. While the camera is under water it is not possible to remove the plates or plate holder in order to substitute a ground glass for them. It is therefore impossible to focus, and the camera must be adjusted to the desired focus before immersing it. This was the method adopted by Boutan in his third apparatus. It would be possible to construct a camera that might be focused under water by means of a focusing scale such as is provided in those hand cameras arranged to be focused without the use of a ground glass, the operator estimating the distance of the object and then setting the camera for a corresponding division on the focusing scale. This method is of value for more distant objects and with rather slow lenses of great focal depth. When very rapid lenses are focused on near objects only those objects are in focus that lie nearly in one plane. Thus a very accurate adjustment of the camera is necessary in order to bring any near object into sharp focus, and this is not possible when the distance of the object must be estimated and the focusing accomplished by means of a scale. In subaquatic photography the objects to be photographed are all near and if instantaneous work is to be done the lens must be very rapid. It is therefore important to be able to focus accurately on the ground glass under water, and this might be accomplished by using two identical cameras (twin camera) united so as to form one instrument. One of these contains the plates and has a lens provided with a shutter. The other camera carries the ground glass. The same focusing mechanism operates both cameras, so that when a sharp image is formed on the ground glass of the one an identical image strikes the sensitive plate in the other when the shutter is operated. One of the cameras serves merely as a focusing finder of full size. A camera of this type properly constructed of metal could undoubtedly be used successfully under water, though it has the disadvantage of being unnecessarily cumbersome and expensive.

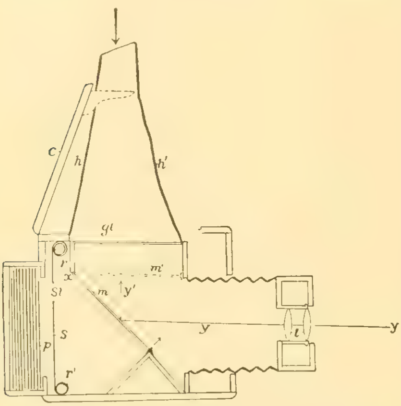

FIG. 9.—A reflecting camera shown in section, with magazine plate holder attached. *gl*, ground glass; *h h'*, hood; *l*, lens; *m*, mirror in position during focusing; *m'*, mirror, showing position during exposure; *p*, sensitive plate; *r* and *r'*, rollers of focal plane shutter; *s*, the shutter; *sl*, slot in shutter; *x*, hinge on which mirror turns; *y y y'*, ray of light traversing the lens and reflected from the mirror to the ground glass.

THE CAMERA.

All of the advantages of the twin camera are to be had by using a reflecting camera, which is at the same time both lighter and less expensive. The principle of the reflecting camera is shown in figure 9, which represents diagrammatically

such a camera in longitudinal section. The ground glass (*gl*) is placed, not at the back of the camera, as is usual, but in the top. The operator, holding the camera in front of him, looks in the direction indicated by the upper arrow, at the ground glass through the hood (h h'), which takes the place of a focusing cloth. The interior of the camera contains a mirror (m), which extends from beneath the back edge of the ground glass downward and forward at an angle of 45°. The mirror is hinged at x to the top of the camera. When it is in the position shown at m in the figure the space between the back of the mirror and the back of the camera is quite dark. Light entering through the lens is reflected by the mirror and strikes the ground glass, as shown by the line y y y'. The image as seen on the ground glass by the operator looking down through the hood is, on account of the action of the mirror, an erect image, not an inverted image such as one sees on the ground glass in the back of an ordinary camera. It is also an image of the full size permitted by the plate and the lens, not a reduced image such as one sees in a finder. The shutter (s) is a focal plane shutter situated at the back of the camera just in front of the plate (p). Such a shutter is essentially a roller curtain of black cloth with a slot (*sl*) across it at one point. The width of the slot may be regulated. The shutter is wound upon an upper roller (r) until the slot is upon the roller. The exposure is made by causing the curtain to unwind from the upper roller (r) and wind upon the lower roller (r') so that the slot passes very rapidly across the face of the plate. The length of the exposure depends on the width of the slot and the rate at which it moves. The rate may be varied by changing the tension of the spring which actuates the lower roller. The operator holds the camera in front of him with both hands while he looks down at the ground glass through the opening in the hood. With one hand he focuses. When the object appears in sharp focus and in the desired position on the ground glass, he presses a button with the other hand. This causes the mirror to swing on its hinge to the position shown by the dotted outline m' beneath the ground glass. In this position the mirror excludes light which might otherwise enter the camera through the ground glass. At the same time the change in position of the mirror permits the light, which was before reflected to the ground glass, to fall upon the plate. The adjustment is such that an image which is in sharp focus on the ground glass will be in sharp focus on the plate when the mirror changes position. The image does not actually strike the plate so long as the shutter is wound upon either roller. Before the instrument is to be used the shutter is wound on the upper roller. When the mirror in swinging upward reaches the position m' the shutter is released from the upper roller and taken up on the lower roller. As the slot passes across the plate from above downward, the image falls through the slot onto the plate in successive strips corresponding to the width of the slot.

The advantages of this form of camera are the following:

1. The operator sees a full sized, erect image on the ground glass, while at the same time the sensitive plate is in position for exposure.

2. He is able to focus and to regulate the position of the image on the ground glass up to the instant of exposure.

3. Much more rapid exposures may be made with the focal plane shutter than with the ordinary diaphragm shutter. The diaphragm shutter occupies a considerable

time in opening and closing, and during the period of operation prevents the light from passing through the full opening of the lens. If the time from the instant a diaphragm shutter begins to open until it is closed again is one one-hunredthd of a second, then a considerable part of this time (usually about 40 per cent) is occupied by the opening and closing. The shutter is then wide open and the lens working at its full opening during only a fraction of the one one-hundredth of a second. With the focal plane shutter, on the other hand, if the slot requires a hundredth of a second to pass a given point on the plate, the lens may be wide open during the whole of that time, so that all the light that the lens is capable of passing reaches the plate during the whole of the exposure. For this reason much more rapid exposures may be made with the focal plane shutter than with the diaphragm shutter.

Various forms of reflecting camera are in the market, and it is possible to obtain a magazine plate holder, which carries 12 plates, arranged to be changed without removing the plate holder from the camera or inserting the dark slide. Such a camera, with the magazine holder, is shown diagrammatically in section in figure 9. It is surprising that Boutan, when he was seeking some means of focusing his camera under water, did not make use of the idea of the reflecting camera; for by merely inclosing such a camera in a water-tight metal box and arranging it to be operated from outside the box, he would have had a portable apparatus capable of being manipulated under water almost as readily as on land. A reflecting camera was manufactured in New York as early as 1886, and was advertised at that time and represented by a Paris agent.

THE WATER-TIGHT BOX.

A 5 by 7 camera of the type just described, with a magazine holder for 12 plates, was used by the writer to obtain submarine photographs at Tortugas, Fla., during the season of 1907. The box (fig. 2, pl. v) to contain the camera was made of galvanized iron by a tinsmith. It measures about 17 inches long, 9 inches high, and 10 inches wide. The front is closed by a square of plate glass cemented with aquarium cement into a groove formed in the metal. At the top is an opening large enough to permit the camera to pass, bottom first, into the box. To the outside of the rim of this opening is soldered half-inch square brass tubing jointed at the corners into a rectangular frame. The upper surface of this frame is made as smooth and as nearly plane as possible. Eight brass screw-bolts are soldered into holes drilled through this frame. They occupy the positions shown in the figure and the threaded end of each projects about three-quarters of an inch above the frame. The cover consists of a flat sheet of metal bordered by a frame of brass identical with that on the box. This frame is perforated by eight openings through which the screw-bolts pass. From the cover there arises an irregular truncated pyramid of galvanized iron, which incloses the hood of the camera. At the top this is closed by a piece of plate glass. By means of wing nuts on the screw-bolts the cover may be tightly clamped to the box, against an intervening gasket of rubber.

On the right hand side of the box is a large milled head of brass from which a brass stem passes to the interior through a stuffing box, which prevents the entrance of the water along the stem. At its inner end the stem terminates in a

two-pronged fork. The stem may be pulled in and out in the stuffing box through a distance of about three-quarters of an inch. When the stem is pushed in, the prongs of the fork engage in two holes drilled in the focusing head of the camera. By turning the milled head on the outside of the box the camera may then be focused. On the opposite side of the box is a second but smaller brass head from which a stem passes through a stuffing box to the interior of the box, and terminates in a flat disk. The disk lies opposite the release pin of the camera by which the mirror and shutter are set in motion. A light spiral spring wound about the stem between the outer head and the stuffing box keeps the stem thrust outward to its full extent. Pressure on the outer head causes the metal disk to strike the release pin so as to make the exposure.

In order to use the box, it is necessary to attach to it a weight heavy enough to submerge all but about the upper 6 inches of the hood. In the experimental apparatus used this weight was made by folding sheet lead to form a flat mass of the dimensions of the bottom of the box. The weight (not shown in the figure) was made slightly wedge shaped lengthwise and was attached to the bottom of the camera by wires passing beneath it and soldered at their ends to the sides of the box. As the camera would, in use, usually be pointed slightly downward, the thicker end of the weight was placed in front, so that the box floated with its front end somewhat lower than its back end.

USING THE APPARATUS.

The apparatus was used in the following manner: The magazine plate holder containing twelve plates was attached to the camera, the mirror depressed, the shutter set at the desired speed and width of slot, and wound. The dark slide was then drawn from the magazine holder, and the camera, thus made ready for an exposure in air, was placed in the box. Metal cleats soldered to the bottom of the box brought it always to the same position. The head on the right of the box was then pushed in until the fork engaged in the holes in the focusing head of the camera. The top was then put on the box and clamped down by the wing nuts as firmly as possible. The apparatus thus made ready was, when in air, as heavy a load as one man could conveniently carry. It was carried to a boat or, if it was to be operated near shore, to the shore. In working with the help of a boat the operator wades on or near the coral reef with his head and shoulders above the water. The boat, with an attendant on board, is anchored near. The operator, with the help of a water glass, now seeks a favorable place for operations. As he moves about the reef, the fish at first seek shelter in the dark recesses of the coral rock, but if he selects a favorable place and remains quiet they soon reappear. They are at first wary, but soon grow bolder and after half an hour or so pay but little attention to him. There is a great difference in wariness among different species of fish. At first only one or two species appear, demoiselles and slippery-dicks usually, then the number of species gradually increases until the shyest butterfly-fish and parrots come within 6 or 8 feet of the operator. He then has the camera passed to him from the boat. It floats with the upper part of the hood protruding and (fig. 1, pl. v) may be easily turned toward any point on the horizon or even tilted so as

to be pointed at a considerable angle upward or downward. The operator has now merely to direct the camera at the fish, while he focuses with his right hand. He must often wait some time before the fish come to the point selected or assume the desired attitude. Often they may be enticed by throwing in a bait of crushed sea urchins or pieces of crawfish. They are in constant motion so that he must as constantly focus. He often misses a long-awaited opportunity because the fish moves on or takes a wrong attitude before he has had time to focus sharply; but when the favorable time comes he presses the release stem and the exposure is made.

The apparatus must then be lifted into the boat, the cover removed from the box, and the camera taken out in order to reset the shutter and change the plate. It is best that all this be done by the attendant who remains in the boat, as the operator is thus left free to watch the fish, while at the same time the fish are not unduly frightened by the sudden movements that he would make in lifting the camera. With care, however, one person may do all the work necessary. He may anchor the boat near, pull it to him by means of a line, lift in the camera, and make all the necessary adjustments while he himself remains in the water. If the work is done near shore, the camera may be carried to shore after each exposure. In that case an assistant is very desirable, since the return of the operator after each absence disturbs the fish. Moreover, when near shore he is moving over the rock or sand bottom, not over the clean upper surface of the reef, and every considerable movement stirs up the bottom sediment so that some time must pass before the water is again clear enough to permit an exposure to be made. If an assistant is available, he may stand at a considerable distance from the operator, who sends the camera box to him through the water by a quick shove. The assistant, after he has carried it ashore and readjusted it, returns it in the same way.

The opening of the box after each exposure occupies some little time, and during this time favorable opportunities to make exposures are often lost. It would be better if a mechanism were provided by which the plates might be changed without opening the box, which would then remain in the water until twelve exposures had been made. Nevertheless it is possible with the apparatus described to make twelve exposures on coral-reef fish in about two hours, including the lifting of the box from the water between exposures and opening it to change plates. Any form of reflecting camera may be used and any form of plate holder. Films may also be used in rolls or packs. In addition to the reflecting camera the operator needs only a metal box of the structure described and of a form suited to his camera. This may be made by any good tinsmith at a cost of a few dollars.

A camera of this type inclosed in a suitable box may be held in the hand while in use, or it may be set upon a tripod of heavy iron, such as is shown in figure 4. Such a tripod would best have a top of the form shown in figure 2, but made of heavy iron instead of wood. The operator may descend in a diving suit, as Boutan did, and use the camera at the bottom in deep water either while holding it in the hand or while it is supported on a tripod. There should be no difficulty in focusing while looking through the plate-glass window of a diver's casque. For work on the coral reefs of the Tortugas, however, the writer has found that everything may be done from the surface, so that a diver's suit is quite unnecessary. He is told that similar conditions exist at the Bermudas. From his own experience in fresh water

he is inclined to believe that probably all the photographic work that it is desirable to do there may be done without the use of a diver's suit. The occasions on which such a suit is really necessary for work in either fresh or salt water are probably extremely rare.

If the objects to be photographed are motionless, or nearly so, time exposures may be made with this apparatus by suitably adjusting the camera before placing it in the box. For this use it is desirable to add to the box a third rod working through a stuffing box and so placed that by means of it the shutter may be released independently of the mirror.

Two photographs made by the method here described are reproduced on plate II. In figure 1, plate I, a butterfly-fish (*Chætodon capistratus*) with a stripe through the eye and an eye-like spot on the tail is seen over a flat expanse of coral (*Meandrina*) and at the base of a large, branching gorgonian. The photograph was taken while the fish was in rapid movement. The expanded polyps may be seen on the gorgonian just above the fish and elsewhere. Figure 2, plate II, shows a group of parrot fishes, of at least three species, and several surgeons against a background of branching gorgonians on a ledge of rock. Near the center is a blue and yellow striped grunt, *Hæmulon flavolineatum*. At the left of this is a blue parrot-fish, *Callyodon cœuleus*. At the right of the grunt is a green parrot-fish, *Callyodon vetula*, about 18 inches long. Beneath the green parrot is a mottled parrot-fish (*Sparisoma?*). Above the grunt is a second mottled parrot and to the left of this a third. At the extreme left are two surgeons, *Hepatus hepatus;* a third is seen below the green parrot. Above the green parrot, in the background, is a purple sea fan, *Rhipidoglossa*. In most of the fish the details of the markings and the outlines of the scales are clearly seen.

These photographs were taken in water about 4 feet deep with a Goerz II. B. lens at a speed of f 5. The exposure was $\frac{1}{25}$ second with Seeds P. orthochromatic plate and a no. 3 graphic color screen. The plates were fully timed and were developed rapidly with a strong pyro developer.

The apparatus used by the writer was experimental only and was meant for temporary use. It is easy to suggest improvements, the greatest of which would be a magazine plate holder for at least twelve plates and capable of being operated from outside the box which incloses the camera. There appears to be no such holder on the market. Magazine holders provided with a bag can not be used even though the leather bag of the plate holder be covered with a rubber bag so attached to the box inclosing the camera that the water can not enter, for the pressure of the water is such that even when the box is but partly immersed the rubber bag is forced into the box through the opening to which it is attached and the holder can not then be manipulated. This difficulty would be increased if an attempt were made to use the apparatus at a greater depth. What is needed is a magazine plate holder that presents a rigid exterior everywhere and that may be operated from the outside of the box by means of rods passing to the inside through stuffing boxes.

The box can be improved by reducing to its lowest limit the number of screws used to fasten the cover, for if but one or two screws had to be loosened to open the box much time would be saved in changing plates.

A part of the weight attached to the bottom of the box should be movable, so that it could be fastened either toward the front or toward the back. In this way the box could be made to float with the lens pointed at a considerable angle toward the bottom or toward the surface of the water. The operator would then be spared the very considerable effort necessary to hold the box in position when the lens is directed much above or below the plane in which the box floats.

The purpose of the writer has been to utilize an ordinary reflecting camera for subaquatic work by inclosing it in a suitable water-tight box without in any way lessening its availability for use in air when removed from the box. For use exclusively in water it would be best to design a reflecting camera that could be immersed directly in water without first inclosing it in a box. Such a camera would have to be of metal, water-tight, and would need to have the lens covered by a plate of glass. It would need to have only a small opening at the back on one side for inserting and removing the plates. Such an opening could probably be readily closed by a cover held in place by one or two screws. A camera of this sort, if made rigid enough to withstand the pressure of the water at even moderate depths, would be too heavy for convenient use in air. It would have the advantage of simplicity and increased ease of manipulation.

SOME LIMITATIONS OF SUBAQUATIC PHOTOGRAPHY.

Turbidity of the water sets a limit to subaquatic photography very much as fog or rain or partial darkness restricts photography in air. The water must be clear—that is, apparently free from particles in suspension. If instantaneous work is to be attempted the water must be free from the reddish color that often tinges fresh-water lakes and streams, for the tinge of red or yellow acts as a color screen and greatly lengthens the time necessary for the exposure.

When one looks from the air into the ocean water at the Tortugas or Bermudas, or into the fresh water of some of our northern lakes, it appears to be as clear as the air itself. When the surface is undisturbed, objects on the bottom at depths of 10 to 20 feet appear with as much clearness as though seen through air alone. The impression is created that such water is actually as clear as air, and that the water would offer no more obstruction to the vision of one beneath it than air itself. To test this impression the writer constructed a reflecting water glass somewhat like a reflecting camera without the lens. It was a metal tube 2 feet long, and contained two parallel mirrors, set at an angle of 45° with its long axis, and placed one at each end. By putting one end of this with its mirror beneath the surface and looking into the mirror at the other end, he obtained a view of the subaquatic landscape such as a diver obtains when he looks about him through the glass window in his casque. It is surprising to find how limited is the range of one's vision under these circumstances. Even in the clear sea water about tropical islands objects at a distance of 20 feet begin to appear indistinct, and beyond that distance they fade into a bluish haze which constitutes the background. This haze has not the effect of fog or smoke or twilight. It is as though the near distance were limited on all sides by walls of bluish translucent quartz which merged into the near water. From these walls the fish emerge and grow

rapidly more distinct as they approach. Into them they vanish suddenly as they recede.

Subaquatic photographs show the same lack of distance that so impresses the eye. Thus in the photographs shown on plate II the distance appears indistinct, partly because the objects in it are out of focus, but chiefly because they are enveloped in the bluish translucence mentioned above. It is therefore impossible under water to photograph objects at any considerable distance. To the photographer who is unfamiliar with the aspect of the subaquatic landscape this lack of distance in photographs of it seems a defect. But to the artist or naturalist who has seen things as they look to one beneath the water it is really a merit, since it shows these things as they are.

The source of this lack of distance is probably double. It is due in part to the fact that even the clearest water contains very many bodies in suspension, living organisms, and inorganic and organic particles. These, like dust in the atmosphere, interfere with distance vision. It is due also in part to the reflection of the light from the surface of the water. Light which has entered the water from above strikes upon and illuminates various bodies beneath the surface. From these a part of it is reflected to the surface of the water again. If it strikes the surface at an angle of more than 48° 35′ with the vertical it is totally reflected and passes again into the water. Here it again strikes some submerged body and is again in part reflected to the surface and here again in part re-reflected. Thus shallow water is traversed in every direction by beams of light which intercross at every angle. These illuminate the opaque particles floating in the water and are deflected by reflection. They are also deflected by refraction through the more transparent organisms. In this way probably is produced the background of bluish-white opalescence which characterizes the subaquatic landscape. To one who knows that landscape, the background, hiding many mysteries, adds to it character and beauty. A photograph that failed to show it would be lacking in character. Boutan (1893), who discusses this subject, made use of a blue color screen and believed that he obtained greater distance in his subaquatic pictures by this means. In his more recent work (1900, p. 283) he abandoned the use of the color screen. He obtained clear pictures of near objects by using a shade above the lens, as already described. Boutan appears never to have obtained clear pictures of more distant objects. The writer has made use of an ordinary yellow color screen (graphic no. 3) but is unable to say with certainty that it adds anything to the distance in his pictures. The subject needs further study.

A second characteristic of the subaquatic photographs that strikes the photographers unpleasantly is their flatness. Objects of all sorts appear lacking in thickness or rotundity and do not cast abrupt or heavy shadows. This peculiarity the writer believes to be due to the reflection of light from submerged objects into the water at the water's surface. Light thus reflected on the subaquatic object from the bottom beneath and from the surface above and at all angles takes out of it much of its roundness. It takes out the shadows very much as a photographer in his studio may take them out by a suitable adjustment of reflecting screens. Along with this flatness of the individual objects in the subaquatic photograph there is abundance of contrast between different parts, as may be seen in plate I.

This lack of distance and this flatness combined with contrast, so characteristic of the subaquatic photograph, are not real defects. They are rather truthful representations of the conditions that actually obtain. To the photographer accustomed only to photographs made on land they appear to be defects. To one who knows the subaquatic landscape they are, from the artistic standpoint, sources of beauty. From the scientific point of view they undoubtedly place limitations on subaquatic photography.

LITERATURE CITED.

Boutan, L.

1893. Memoirs sur la photographie sous-marine. Archives de Zoologie expérimentale et générale, ser. 3, t. I, p. 280–324, pl. XVIII and 4 fig.

1898. L'instantané dans la photographie sous-marine. Comptes rendus de l'Académie des Sciences, Paris, t. CXXVII, p. 731–733 (Novembre).

1898a. L'instanté dans la photographie sous-marine. Archives de Zoologie expérimentale et générale, ser. 3, t. VI, p. 299–330, pl. XX–XXIII, 8 fig.

1900. La photographie sous-marine et les progrès de la photographie. Paris, 1900, 332 p., 52 fig., 12 pl.

Fabre Domergue.

1898. Photographie d'aquarium. Photo-Gazette, vol. VII (8).

Jordan, D. S., and Evermann, B. W.

1902. American food and game fishes. 573 p., illus. New York. (Contains many photographs from life by A. Radclyffe Dugmore.)

Reighard, Jacob.

1903. The natural history of Amia calva Linnæus. Mark Anniversary Volume, p. 57–109, pl. VII. (Plate reproduced by lithography from colored photographs of *Amia*.)

Rudaux, L.

1908. La photographie à travers l'eau. La Nature, no. 1824, 9 Mai, 1908, p. 360–363. (Translation in Literary Digest of June 13, 1908.)

Saville-Kent, W.

1893. The Great Barrier Reef of Australia. Its products and potentialities. London, p. I–XVIII+1–387. Photo-mesotype pl. I–XLVIII, chromo pl. I–XVI.

Shufeldt, R. W.

1898. The camera and the aquarium. Photo Era, vol. II, p. 147–150, 3 fig.

1899. Experiments in photography of live fishes. Bulletin U. S. Fish Commission, vol. XIX, 1899, p. 1–5, pl. 1–9.

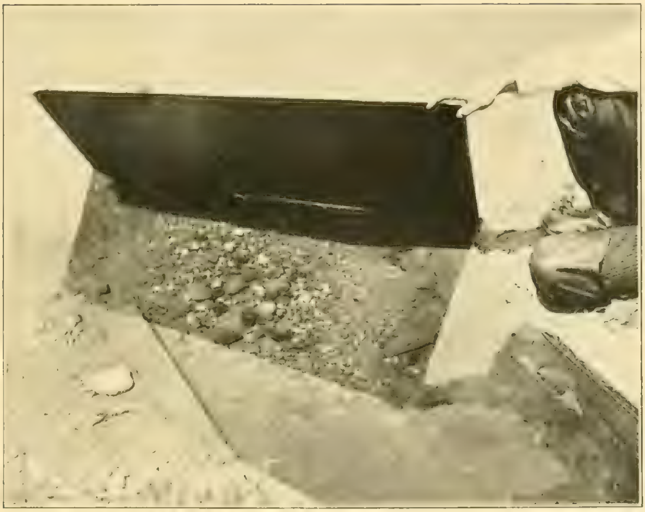

FIG. 1. PHOTOGRAPH OF THE NEST OF A SMALL-MOUTHED BLACK BASS (MICROPTERUS DOLOMIEU) TAKEN WITH THE AID OF A SCREEN THE CAMERA ABOVE WATER

FIG. 2. BROOK LAMPREYS (LAMPETRA WILDERI) ON THE NEST, PHOTOGRAPHED THROUGH THE WATER GLASS SHOWN IN FIGURE 2, PLATE IV, IN ABOUT 8 INCHES OF RUNNING WATER.

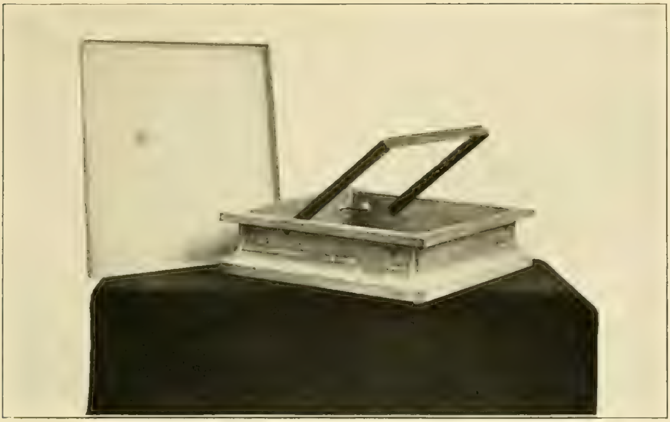

FIG. 1. WATER GLASS DESIGNED BY THE WRITER TO BE USED FOR OBSERVATION OR PHOTOGRAPHY OF OBJECTS UNDER WATER

The cover is shown at the left

FIG. 2. TWO-FOOT WATER GLASS SUPPORTED ON FOUR LEGS AND PROVIDED WITH SCREEN, AS USED FOR STUDYING AND PHOTOGRAPHING LAMPREYS LAMPETRA WILDER

FIG. 1. PHOTOGRAPH SHOWING THE METHOD OF USING THE REFLECTING CAMERA WHEN INCLOSED IN THE WATER-TIGHT BOX FOR SUBAQUATIC WORK

The upper part of the box covering the hood rises above the surface, while the lower part, containing the camera proper, is under water. The operator is looking into the hood through the plate glass in the top of the box. With his right hand he focuses; with his left makes the exposure.

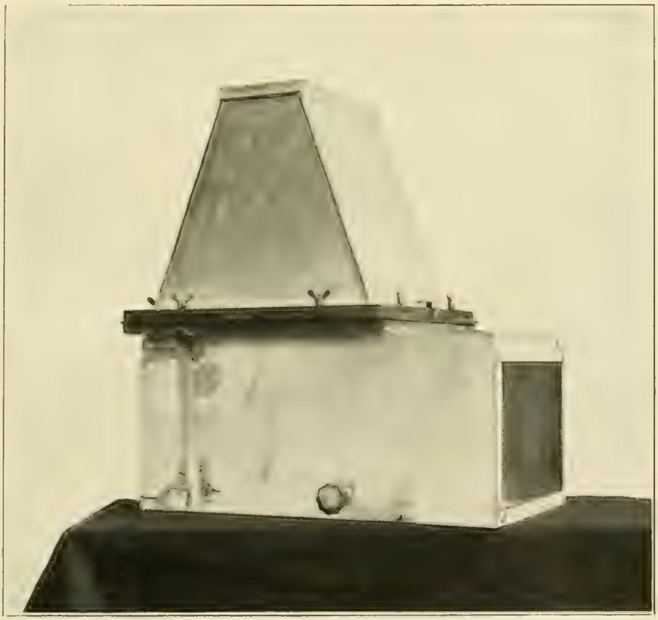

FIG. 2. GALVANIZED-IRON BOX WITH PLATE-GLASS FRONT, DESIGNED BY THE WRITER TO CONTAIN A 5 BY 7 REFLECTING CAMERA WHEN USED UNDER WATER

For description see text, page 62

RELATIONSHIPS OF THE FISH FAUNA OF THE LAKES OF SOUTHEASTERN OREGON

By JOHN OTTERBEIN SNYDER

Assistant Professor of Zoology, Leland Stanford Junior University

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BUREAU OF FISHERIES DOCUMENT NO. 636

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By JOHN OTTERBEIN SNYDER,
Assistant Professor of Zoology, Leland Stanford Junior University.

INTRODUCTION.

In the summer of 1897 a party[a] sent out by the Commissioner of Fisheries examined a number of the lakes and streams in southern Oregon, leaving Ashland, Oreg., July 15 with camping outfit and remaining in the field until August 15. The region visited is that lying near the southern boundary of Oregon between Ashland on the west and the Warner Lakes on the east. The entire distance traveled by this party exceeded 700 miles, through the lava beds, marshes, and semidesert region of this part of the state.

The following lakes and streams were examined, and collections of their fishes and other aquatic life were made: Spencer Creek, July 16; Lower Klamath Lake, July 17 and 18; Whisky Creek, Spring Creek, and Sprague River, July 19; Drews Creek, at Howard's ranch, July 20; Goose Lake, at Farrington's, and New Pine Creek, near Farrington's, July 21–27; Camass Creek, at Hog Ranch, July 27; Camass Creek, Mud Creek, and Blue Creek, July 28; Honey Creek, near Plush, and Christmas Lake (of the Warner Lakes group), July 29–30; Abert Lake and mouth of Chewaucan River, August 1–2; Chewaucan River, near Paisley, August 3–4; small creek and pond at Harris's ranch, at Summer Lake post-office, August 4–5; large spring which forms Summer Lake River, August 5; Silver Lake, at Duncan's ranch, August 6; Silver Creek, near Silver Lake post-office, August 7; Bear Creek, at Bear Flat, August 8; Yansic Creek, on head of Williamson River, August 8; Klamath Marsh, August 9; Spring Creek, near Klamath Agency, August 10; Pole Creek and Crater Lake, August 12; Union Creek and Rogue River, August 13; Elk Creek and Trail Creek, August 14, and Rogue River, August 15.

In July and August, 1904, another party[b] covered a distance of about 1,000 miles with horses and wagon, hastily examining the basins of Malheur, Warner, Abert, Summer, Silver, Alkali, and Goose lakes, together with the upper portion of Pitt River.

In addition to the large series of specimens obtained by these expeditions, collections from the Sacramento, Klamath, and Columbia rivers, belonging to the

[a] This party was in charge of Dr. Barton W. Evermann, of the Bureau of Fisheries, who was assisted by Prof. William P. Hay, Mr. Toxaway B. Evermann, and Mr. Charles M. Rowe, of Washington, D. C., and Mr. William E. Butler, of Ashland, Oreg.

[b] Composed of the writer, Prof. E. C. Starks, and Messrs. E. L. Morris and J. D. Snyder.

Bureau of Fisheries, have been used in the preparation of the present paper, as were also the large collections belonging to the Bureau of Fisheries.[a]

CHARACTER OF THE LAKES.

The lakes of southeastern Oregon are on a high, semiarid plateau, a portion of which, having interior drainage, may be included in a northwestern arm of the Great Basin. The region has a general elevation of about 4,000 feet. It is mostly a desert, except where the mountains, reaching a sufficient height, form forested areas of considerable humidity. The streams flowing from these mountains are often of large size, and the water, being clear and cool, supports trout in great numbers and of excellent quality. The marshes and lakes attract myriads of water birds, many of which show little fear. The entire region, although in most places desolate and forbidding, is one of particular interest, possessing a scenic beauty entirely its own. On every side are the well-preserved remains of the past activity of geological forces, while the fauna and flora are especially attractive to the naturalist.

Warner Lake lies in a series of shallow depressions in the nearly flat floor of a valley 50 miles long and from 4 to 8 miles wide.[b] It receives its water almost entirely through streams flowing from the Warner Mountains lying to the westward. These mountains rise to a height of perhaps 7,000 feet and are well timbered, large pines extending downward to an elevation of about 5,000 feet, where they mingle with the junipers and sagebrush of the table-lands. Late in July large patches of snow are yet to be seen to the west and southwest, where head the principal tributaries of the lake—Honey, Warner, and Twenty-Mile creeks. Tongues from the timber belt extend downward along the upper courses of the creeks, which occasionally flow through mountain meadows often of large size. Warner Creek has cut a magnificent canyon, through which it plunges from the great plateau down into the lake basin beneath. The water passes over a basaltic dyke a short distance from the mouth of the canyon, producing a picturesque fall some 25 feet in height.

The lake is divided into three distinct parts. A transverse ridge of volcanic origin several hundred feet high cuts off a southern third except for a narrow channel, where the water may flow through to the northward. The northern third is completely divided from the central portion by a ridge of sand 10 or 15 feet high and of considerable width. This may at times act as a dam, but it can hardly prevent seepage from one portion of the lake to the other. The water on both sides of the ridge when seen by the writer was fairly fresh, while at the northern end of the lake it was extremely alkaline, nothing growing along its border. All parts of the lake are said to be shallow. The water is very turbid, the bottom being hidden at a depth of a foot.

Immediately north of the volcanic ridge the eastern border of the basin abruptly rises to a great height, the walls being in some places almost sheer cliffs. Seen from the south this elevation resembles a high, circular mesa. In passing to the

[a] Acknowledgments are due to Dr. C. H. Gilbert for kindly advice and many valuable suggestions during a study of the distribution of western fishes.

[b] The distances and elevations given here are the results of estimates made in the field, an aneroid barometer being frequently used.

north, however, it soon becomes apparent that what before appeared as a flat-topped mountain is really a great wall which rises some 1,800 feet above the floor of the basin, and with only slightly varying height extends almost to the northern boundary. South of the transverse ridge the basin is bordered by bluffs and ranges of hills which gradually rise perhaps a thousand feet as they recede from the valley. Swinging round to the westward the bordering heights assume greater proportions and are more abrupt. North of Honey Creek they become broken, falling away into rounded hills and low plateaus. In the northern part of the basin a definite and well-preserved shore line extends along nearly the entire face of the eastern escarpment. It appears to be somewhat over 300 feet above the floor of the valley.

Abert Lake occupies part of a basin which is somewhat similar to that of Warner Lake, bordered by a high, precipitous wall on the east and low bluffs and rolling hills on the west. It is about 15 miles long and nearly a third as wide. The water of the lake, said to be not over 18 feet deep, is muddy and intensely alkaline, nothing growing near it.[a] It is fed almost entirely by the Chewaucan River, which drains the northeastern part of the Winter Mountains, where they are covered with forests, especially on the slopes exposed to the south and west. Deep snow lying late in the season and an abundance of rain give the river a large volume of clear, cold water. After emerging from the mountains it flows, a deep, sluggish stream, across the great Chewaucan Marsh and finally passes over a fall into the lake.

At the north end of Abert Lake, on the XL Ranch, is a remarkable spring. Its water has a temperature of 61° F., is said to be constant in volume, clear, and fresh. It pours at once into a boggy pool 100 feet in diameter and about 17 feet deep, from whence an outflowing stream spreads over a marsh of tules and rushes. The water of the pool is clouded with algæ and swarms with fishes (*Rutilus*). A handful of crumbs thrown out on the surface attracts great numbers, causing the water fairly to boil, the food disappearing almost instantly. One haul of a seine net inclosed hundreds of specimens measuring from a few inches to nearly a foot in length. Their stomachs were stuffed with vegetation and numbers of a minute gasteropod. Whether the fishes derive their entire support from the pool was not learned. A few were seen in the stream leading from the pool, and it is reported that during wet weather great numbers pass out to the marsh, where they are left to die as the dry season approaches. The fishes are no doubt natives of the spring, the species having been left by the retreat of the desiccating lake.

Summer Lake is somewhat smaller than Abert. It is muddy, alkaline, and very shallow, the greatest depth not exceeding 15 feet, and much of that is soft mud. The bottom slopes very gently from the shore, avocets being able to wade out over a hundred feet. Consequently a slight reduction in the volume of water contracts the area of the lake considerably. It has maintained its present level for at least forty years, as stated by residents of the valley, the shore line occasionally retreating, however, during dry seasons as much as 150 yards. Sometimes a strong wind will drive the water back 200 yards or more, when a long reef of the stumps and fallen

[a] Cope (Proceedings Academy Natural Sciences Philadelphia, 1883, p. 138) says: "It abounds in fishes, especially the trout *Salmo purpuratus*." Residents of the region report that fishes may often be found in the lake at the mouth of the Chewaucan River, where many, having passed over the fall, die from contact with the alkaline water.

trunks of gigantic willows are exposed, conclusively showing that for a considerable time during its past history the lake was much smaller than at present. The principal source of water supply is Ana River, a stream unique in many particulars. It rises from a group of several springs which pour out clear, cool water, forming a stream about 15 feet wide and 4 feet deep with a current so swift that it is difficult to stand against it. It is not more than 5 miles long and flows in a deep channel cut in the floor of the lake basin. Sagebrush and other desert plants grow to its very edge and, judging from the landscape alone, no one 200 yards from either the springs or river would suspect their presence. Some of the springs form large pools apparently of great depth, which are held in conical basins, the surface of the water lying 50 or more feet below their rims. The temperature of the water is 60° F., reported to be constant throughout the year.

The Rim Rock Mountains tower perhaps 2,000 feet above the western side of the lake. Their slopes are very steep, in some places dropping off in precipitous cliffs of great height. Their crests are covered with trees, small pines and junipers extending in some places far down their sides. At the base of the mountains along nearly the entire western side of the lake is a narrow belt of meadows and marshes, kept green by springs and small rivulets. The east side of the lake is barren and desolate in the extreme. The water is bordered by extensive mud flats, beyond which are great wastes covered with alkaline dust or shifting sand, the sand piling up against the low hills which skirt the valley. In the distance the hills and bluffs gradually rise to a height approaching a thousand feet.

Summer Lake is separated from the Chewaucan Marsh by only a slight elevation. Between Summer and Silver lakes is a divide apparently not less than 500 feet high.

Silver Lake Valley is bordered on the west by a high basaltic wall, which, though more or less broken by hills and canyons, continues well around the southern end. On the eastern side of the valley this same wall rather abruptly slopes down to a point where the ancient outlet is said to be located, again to rise and extend to the northward with an irregular outline of hills and mesas.

The inlet of the lake comes from the Pauline Marsh, lying to the northward, which in turn receives Bear, Bridge, and Silver creeks, streams of considerable size, draining the northern ranges of the Winter Mountains. The water of the lake, which is turbid and slightly alkaline, was at its maximum height when seen by the writer. It covered nearly the whole floor of the southern part of the valley and no beaches appeared above its level. This condition was said to be only temporary, however, the size of the lake being subject to considerable variation. Not long ago it contracted until nearly dry, remaining so for a year or more. At the time many dead stumps of sagebrush were found standing where they once grew, far within the present shore line.

Alkali Lake is an extensive pond lying in a desolate and forbidding region about 20 miles north of Abert Lake. It is the desiccated remains of a former great lake which was probably over 200 feet deep. On the low land not far from the shore is a spring pool about 50 feet across. Its water is fresh, slightly turbid, and is said to remain at a temperature of about 64° F. It swarms with fish (*Rutilus*), great numbers coming to the surface on the appearance of food. Many

may also be seen swimming about among clumps of algæ in the stream flowing from the spring. They are smaller than those found in the spring at Abert Lake.

Malheur and Harney lakes are extensive bodies of alkaline water. They are in a huge basin with a nearly flat floor, bordered in many places by great walls of basaltic rim rock. Malheur Lake receives the Donner and Blitzen River, flowing from the Stein Mountains on the south, and the Silvies River, which drains a part of the mountainous region to the northward. Harney Lake, the deeper and more salty of the two, often acts as an overflow basin for Malheur Lake. It is also fed by Silver Creek and a group of large, warm springs on the western side which have a constant temperature of 70° F. A stream of considerable size and several pools fed by these springs harbor great numbers of minnows.

Altogether the lakes receive the drainage of a vast territory, the tributary streams increasing the amount of water greatly during the winter and spring. As the dry season progresses the inflow diminishes and the evaporation increases, while the lakes rapidly contract and their salinity grows more pronounced. The constantly widening mud flats, with their glistening surfaces, and the drying up of the marshes add greatly to the general desolation of the valley.

Harney and Malheur lakes are separated from Warner, Abert, Summer, and Silver lakes by a broad, desolate expanse of sage plains and sandy desert, scored by the dry channels of ancient rivers and sparsely dotted with small playa lakes which contain water for only a short time during the year.

The Malheur basin was once drained by the Malheur River, a part of the Columbia system. There is evidence [a] to show that it was cut off from that system by volcanic action in comparatively recent geological times. The basins of the other lakes are completely and widely isolated from any system having connection with the ocean. Although little appears to be known of their geological history, they may for the present be regarded as unconnected parts of what may be termed the Oregon lake system. It is to be noted that the lakes of this group receive their water supply from a mountainous region on the southwest. A large portion of this same territory is drained by streams which flow into Klamath and Rhett lakes to the westward, and also by others connected with Goose Lake, lying farther south. It is well known that Klamath and Rhett lakes are integral parts of the Klamath River system.[b] Goose Lake belongs with the Sacramento system, although the water seldom rises high enough to flow out through the broad channel leading from the lake to Pitt River. In appearance it is very different from the lakes of the Oregon system. The basaltic rim rock so characteristic of the region to the northward is almost entirely wanting, while in its stead the lake is surrounded by a gently sloping, fertile valley, the northern portion of which is very broad and

[a] Russell, Israel C., Notes on geology of southwestern Idaho and southeastern Oregon, Bulletin U. S. Geological Survey No. 217, p. 22.

[b] Rhett or Tule Lake formerly had an indirect connection with Klamath River through Lost River Slough. The lake served at times as an overflow basin for Klamath River. In a letter on the subject Mr. Elmer I. Applegate, of Klamath Falls, writes: "Until a few years ago Lost and Klamath rivers were connected by what was known as Lost River Slough, which carried a stream of considerable size during high water, offering no obstruction during a large portion of the summer to the passage of all fishes inhabiting the waters of either river. No water passes through this channel now, it having been diked in order to confine the water to Klamath River, and thus lower the level of Tule Lake."

low, a considerable part of it being inundated most of the time and covered with a rank growth of tules. Toward the south the tule belt rapidly narrows and the valley slopes a little more abruptly up to the mountains. On the eastern side the mountains rise about 3,000 feet and are well timbered, large pines in many places extending down almost to the water's edge, while west of the lake they are much lower and support very few trees. The lake is said to be shallow, its greatest depth not exceeding 25 feet. On approaching the water an old beach of coarse gravel and small boulders may be observed, indicating that the surface has been 6 or 8 feet higher in the recent past. In wading out somewhat over 200 yards, where one's depth is reached, two other well-marked beaches are crossed. During very dry seasons the first of these is laid bare. An elevation of the surface of the water to the height of the outermost beach would cause the lake to overflow, pouring out through the channel leading to the southward. The lake receives numerous streams flowing in from all sides, Drew and Cottonwood creeks, which rise in the Winter Mountains, being the largest. Along the eastern side are many small streams of clear, pure water, the more important of which—Fandango, Lassen, and Davis creeks—are fed late in the summer by banks of snow lying high in the mountains.

LOCAL DISTRIBUTION AND RELATIONSHIPS OF THE FISH FAUNA.

In a discussion of the fish fauna of the lakes of southeastern Oregon it is necessary to keep in mind the relative position of their respective basins, and to simplify this matter an outline map of the region is presented (facing p. 102).

It has been observed that the Malheur basin is closely related, both geographically and geologically, with the Columbia. The first haul of the seine-net in Silvies River, which brought out such forms as *Acrocheilus alutaceus* and *Ptychocheilus oregonensis*, indicated plainly that it also bears a close faunological relation with that system. A careful examination of available material fails to show that the fishes which are isolated in the Malheur basin have visibly differentiated from their congeners in the Columbia. A still closer affinity exists between the fishes of the Klamath and Goose Lake basins and the river systems with which they are each connected by open or temporary waterways.

In an examination of the relationships of the fauna of what has been termed the Oregon lake system, one immediately turns to the species inhabiting the neighboring basins. The close proximity of the Sacramento, Klamath, and Columbia systems has been referred to, and it appears that with certain species found in these rivers the Oregon lake fishes are most intimately related. On a survey of the aggregate fish fauna of these river systems it seems that the various species may be divided for certain reasons into three fairly well defined series or groups. In the first series there may be brought together an assemblage of forms that are anadromous, or at least able to withstand salt water. They are the lampreys, sturgeons, sticklebacks, cottoids, trout, and salmon. Species of this group are generally distributed throughout the three systems or else are represented in each by closely related forms.[a] To a second series may be assigned a number of distinctly fresh-

[a] Certain cottoids, as *C. princeps*, *C. rhotheus*, and others, whose relationships have not been carefully studied, might be included in this group as having probably descended from marine forms.

water forms, widely differentiated species, many of which constitute peculiar genera characteristic of the basins in which they occur. They are *Orthodon microlepidotus*, *Lavinia exilicauda*, *Mylopharodon conocephalus*, *Pogonichthys macrolepidotus*, *Leuciscus crassicauda*, and *Rutilus symmetricus*, of the Sacramento; *Chasmistes brevirostris*, *Chasmistes stomias*, *Chasmistes copei*, and *Deltistes luxatus*, of the Klamath; *Pantosteus jordani*, *Acrocheilus alutaceus*, *Rhinichthys dulcis*, *Couesius greeni*, *Leuciscus caurinus*, *Columbia transmontana*, and others, of the Columbia. Each species included in this series is limited in its distribution to a single river basin and it is not represented in another by a closely related form. A third series, consisting, like the second, of fresh-water species, differs notably, however, in that each of its members is represented in at least one other than the native basin by a closely related form. To make this statement more clear a single example may be cited. There is in each of the three basins a large-scaled catostomid—*Catostomus occidentalis* in the Sacramento, *C. snyderi* in the Klamath, and *C. macrocheilus* in the Columbia. These resemble one another so closely as to be difficult to distinguish, and their characteristics are such as point directly to the probability of a common origin of the three forms. The species which may be assembled in this series, and which appear to bear out the general observation concerning its members, are here tabulated.

Sacramento.	Klamath.	Columbia.
Catostomus occidentalis	Catostomus snyderi	Catostomus macrocheilus.
Catostomus microps	Catostomus rimiculus	Catostomus catostomus.
Rutilus thalassinus	Rutilus bicolor	Rutilus columbianus.
....	Leuciscus bicolor	Leuciscus balteatus.
Agosia nubila carringtoni	Agosia klamathensis	Agosia nubila carringtoni.
Ptychocheilus grandis	....	Ptychocheilus oregonensis.

Turning again to the Oregon lake system, it will be found, as is shown in the more detailed part of this paper, that the immediate affinities of its fish fauna are with those species of the Sacramento, Klamath, and Columbia rivers which, except the trout,[a] have been assembled in the third series of the above scheme. Moreover, the bond of relationship indicated by a similarity of structure of the representative forms in the different basins is so strong as to leave little doubt of a community of descent.

Cope traced a close affinity between the Oregon lake (including also Goose and Klamath lakes) and the Lahontan systems, and such a relationship no doubt exists. It is only relative, however, as an examination of the representative species will show. *Rutilus oregonensis* differs from *R. olivaceous* in important dental characters which are of at least subgeneric value. Between *Catostomus warnerensis* and *C. tahoensis* the difference is not so great, yet the bond of relationship appears to be no closer than it is between *C. warnerensis* and allied forms in the Columbia and Sacramento rivers. Although the status of the described forms of *Agosia* is not well understood, the examples from the Oregon lake system much more closely resemble the form known as *A. klamathensis* than that found in the Lahontan system.

The present study has not only shown what is believed to be the true relationships of the Oregon lake fishes, but it has also pointed out an affinity existing

[a] The relationship of the trout is in line with the other species, the same form being found in the Sacramento, Klamath, and Columbia rivers.

between certain elements of the aggregate fish fauna of the Sacramento, Klamath, and Columbia rivers not hitherto known. A simple explanation for these interrelationships offers itself when some attention is given to the geography and geology of the region. The close proximity of many tributaries of the three systems, which appears to have been even more pronounced in a past geological period, has probably made possible an intermingling of their waters, thus permitting the passage of individuals of certain species from one basin to another, where their descendants, being able to maintain themselves, have in most cases become sufficiently differentiated to be recognized as distinct species.

TABLE SHOWING DISTRIBUTION OF THE FISH FAUNA.

Sacramento River system.

Species.	Goose Lake Basin.				Sacramento River Basin.					
	Cottonwood Creek, Oreg.	Drew Creek, Oreg.	Muddy Creek, Oreg.	Goose Lake, Cal.	Joseph Creek, Cal.	Pitt River near Alturas, Cal.	Pitt River near Canby, Cal.	Pitt River, Big Valley, Cal.	Rush Creek near Adin, Cal.	Burney Creek at Burney.
Entosphenus tridentatus										
Catostomus occidentalis										
Mylopharodon conocephalus										
Ptychocheilus grandis										
Rutilus symmetricus	×									
Rutilus thalassinus	×									
Agosia nubila carringtoni	×									
Salmo clarki	×									
Cottus gulosus										

Oregon Lake system.

Species.	Warner Basin.			Chewaucan Basin.			Summer Lake Basin.			Silver Lake Basin.					Alkali Basin.
	Warner Creek.	Honey Creek.	Warner Lake north of Honey Creek.	Chewaucan River, Paisley.	Chewaucan River near mouth.	XL Spring, Albert Lake.	Spring at Summerlake P. O.	Ana River near mouth.	Springs, source of Ana River.	Silver Lake at Duncan Ranch.	Silver Creek near mouth.	Silver Creek near Silverlake P. O.	Bridge Creek.	Buck Creek.	Spring at Alkali Lake.
Catostomus warnerensis	×	×													
Rutilus oregonensis	×	×												×	×
Agosia nubila carringtoni	×	×												×	
Salmo clarki	×	×												×	

Columbia River system.

Species.	Malheur Basin.		
	Silvies River near Burns.	Silver Creek near Riley.	Warm Springs.
Catostomus macrocheilus	×		
Catostomus catostomus	×		
Acrocheilus alutaceus	×		
Ptychocheilus oregonensis	×		
Leuciscus balteatus	×		×
Rutilus columbianus	×		×
Agosia nubila carringtoni			×
Salmo clarki	×		
Cottus punctulatus			

SYSTEMATIC DISCUSSION.

EXPLANATION OF MEASUREMENTS.

It is intended that the tables of measurements given in this paper, besides being of use in the identification of the species under consideration, shall express the amount and character of the variation in certain details of structure as well as these can be determined by the study of a small series of specimens. It is presumed that the true relationships of the forms will be more clearly and definitely

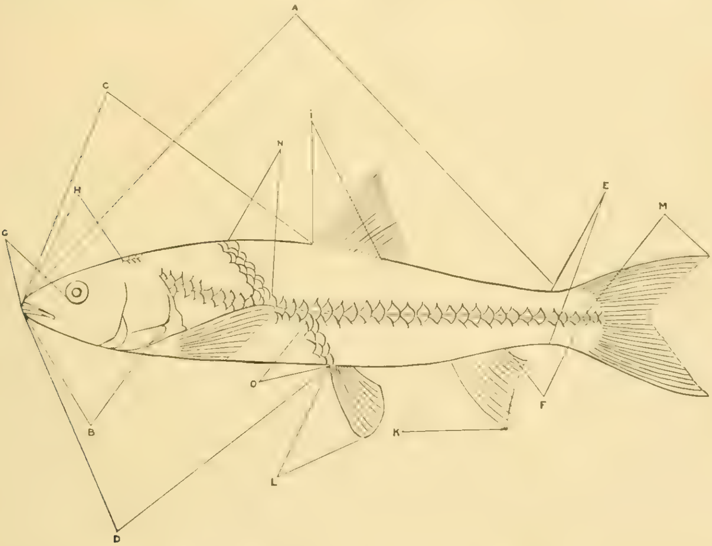


FIG. 1.—Diagram showing method of taking proportional measurements.

Length of body (*a*) recorded in millimeters. *Length head* (*b*) measured from tip of snout to posterior edge of opercle, the opercular flap, which is likely to shrink, not being considered. *Depth head*, measured at occiput. *Depth body*, the greatest depth. *Snout to dorsal* (*c*), *snout to ventral* (*d*), tip of snout to anterior end of base of fin. *Depth caudal peduncle* (*e*) measured at the narrowest place. *Length of caudal peduncle* (*f*), base of posterior anal ray to end of last vertebra; not to base of lowermost caudal ray, as the latter point is often indefinite. *Length snout* (*g*), tip of snout to anterior border of eye. *Diameter eye*, varies greatly with age. In poorly preserved specimens the tissue surrounding the eye is often shrunken, leaving the opening abnormally large. Only well-preserved examples nearly equal in size ought to be compared. *Interorbital width*, measured on skull, the points of the dividers being closed as nearly as possible between the eyes. *Snout to occiput* (*h*), tip of snout to the point on occiput where scales of body first appear. *Length base of dorsal* (*i*), *length base of anal*, from base of anterior to base of posterior ray, the extent of the membrane posteriorly not being taken into account. *Height dorsal*, *height anal* (*k*), *length pectoral*, *length ventral* (*l*), the length of longest ray in fin. *Length caudal* (*m*), measured from end of last vertebra to tip of upper caudal lobe. *Scales lateral line*, counted to end of last vertebra; not on base of caudal, where they frequently become densely crowded and difficult to make out. *Scales above lateral line* (*n*), from lateral line upward and forward to a point about midway between occiput and insertion of dorsal; not between lateral line and base of dorsal, as in the latter region the scales are sometimes minute, densely crowded, and indistinct. *Scales below lateral line* (*o*), from upper edge of base of ventral upward and forward to the lateral line. The series in the lateral line is not enumerated in this or the previous count. *Scales before dorsal*, the number of rows or series between occiput and base of dorsal. *Dorsal rays*, *anal rays*, when the posterior ray is cleft to the base it is still counted as a single ray. The anterior ray is often simple and preceded by one or two short, spine-like rays closely united to it. The spine-like rays are not enumerated.

set forth than when such expressions as "closely related," "its affinities are with," and the like are alone used. In many cases the results of comparative measurements of certain parts are merely negative. They are valuable, however, and are generally recorded. Characters which for one reason or another may at once be determined valueless, such as the number of caudal rays, occasionally the depth of the body, etc., are omitted.

The measurements have been made by means of a proportional scale, from carefully prepared specimens. They are expressed in hundredths of the length of the body (which is recorded in millimeters), measured from the tip of the snout to the end of the last caudal vertebra. (See diagram, p. 79.)

CATALOGUE OF SPECIES.

Entosphenus tridentatus (Gairdner).

Goose Lake, Pitt River near Alturas, and Burney Creek.

Catostomus occidentalis Ayres.

Drew Creek, Muddy Creek, and Cottonwood Creek, in Lake County, Oregon; Goose Lake, Pitt River, in California.

MEASUREMENTS OF SPECIMENS OF CATOSTOMUS OCCIDENTALIS FROM GOOSE LAKE, CALIFORNIA.

Length of body.....mm..	255	265	235	248	190	236	255	222	222
Length of head	.235	.225	.225	.24	.235	.226	.23	.23	.235
Depth of body	.205	.20	.205	.215	.195	.21	.19	.20	.225
Snout to dorsal	.50	.495	.485	.505	.505	.51	.50	.515	.51
Snout to ventral	.59	.585	.555	.565	.575	.57	.585	.575	.545
Depth of caudal peduncle	.09	.093	.08	.085	.09	.085	.085	.03	.085
Width of lower lip	.05	.055	.045	.05	.045	.05	.045	.05	.05
Length of snout	.12	.115	.115	.115	.125	.105	.11	.105	.115
Diameter of eye	.035	.035	.04	.04	.04	.04	.037	.04	.04
Depth of head	.185	.17	.17	.175	.17	.165	.17	.17	.165
Height of dorsal	.155	.165	.165	.18	.165	.155	.175	.165	.175
Height of anal	.185	.195	.245	.235	.175	.19	.185	.195	.215
Length of pectoral	.21	.205	.22	.21	.20	.21	.19	.215	.215
Length of ventral	.15	.155	.165	.17	.145	.15	.145	.155	.16
Length of caudal	.23	.23	.23	.23	.245	.23	.225	.23	.23
Dorsal rays	12	12	11	12	13	12	12	11	11
Scales of lateral line	73	73	72	63	72	72	63	67	70
Scales above lateral line	15	16	15	14	15	15	16	17	16
Scales before dorsal	35	37	36	34	38	39	36	35	37
Length of body.....mm..	181	130	153	156	141	140	155	133	131
Length of head	.24	.24	.235	.25	.24	.24	.233	.24	.245
Depth of body	.21	.22	.23	.225	.22	.22	.215	.22	.215
Snout to dorsal	.48	.485	.51	.515	.50	.51	.49	.50	.52
Snout to ventral	.555	.58	.57	.585	.575	.57	.55	.59	.60
Depth of caudal peduncle	.085	.09	.083	.085	.08	.09	.08	.09	.08
Width of lower lip	.05	.065	.04	.045	.05	.055	.045	.047	.055
Length of snout	.11	.115	.11	.12	.11	.11	.105	.115	.115
Diameter of eye	.04	.05	.045	.04	.045	.045	.045	.047	.05
Depth of head	.17	.18	.165	.17	.18	.165	.155	.18	.18
Height of dorsal	.175	.19	.195	.18	.17	.18	.165	.19	.18
Height of anal	.185	.20	.21	.22	.185	.20	.18	.185	.20
Length of pectoral	.21	.22	.225	.23	.22	.21	.195	.20	.22
Length of ventral	.15	.17	.17	.165	.15	.17	.15	.155	.16
Length of caudal	.235	.25	.255	.265	.25	.21	.23	.24	.25
Dorsal rays	12	12	11	13	11	12	11	11	11
Scales of lateral line	67	65	66	67	65	63	66	70	64
Scales above lateral line	16	16	15	16	15	15	17	15	15
Scales before dorsal	32	35	36	37	36	33	38	34	32

TABLE SHOWING NUMBER OF RAYS IN DORSAL FIN OF CATOSTOMUS OCCIDENTALIS FROM DIFFERENT LOCALITIES IN THE SACRAMENTO BASIN.

Dorsal rays.	Cotton-wood Creek.	Drew Creek.	Goose Lake.	Cache Creek, Yolo County, Cal.
	Specimens.	*Specimens.*	*Specimens.*	*Specimens.*
11	3	1	6	
12	40	9	13	15
13	5	2	1	5
14	2			2

Catostomus macrocheilus Girard.

A few specimens were collected from the deeper parts of the Silvies River, near Burns. They agree in all details with examples from the Columbia.

This species and *C. occidentalis* of the Sacramento appear to be very closely related. They resemble each other perfectly in general appearance except that the Columbia form seems to have a smaller eye and shorter and more rounded pectoral fins. The scales are alike in both cases, and the fin rays are about equal in number.

MEASUREMENTS OF SPECIMENS OF CATOSTOMUS MACROCHEILUS FROM SILVIES RIVER, NEAR BURNS, HARNEY COUNTY, OREG.

Length of body ..... mm..	160	167	156	150	152	150	140	124	96	95
Length of head	.24	.26	.25	.25	.25	.25	.26	.255	.26	.25
Depth of body	.235	.23	.235	.22	.24	.23	.245	.24	.23	.235
Snout to dorsal	.525	.525	.52	.52	.525	.52	.54	.525	.53	.525
Snout to ventral	.575	.58	.57	.595	.58	.595	.59	.595	.60	.58
Depth of caudal peduncle	.075	.08	.08	.075	.075	.075	.077	.08	.08	.075
Width of lower lip	.045	.05	.05	.05	.05	.046	.05	.05	.05	.042
Length of snout	.125	.13	.125	.125	.12	.115	.13	.125	.12	.11
Diameter of eye	.05	.045	.045	.05	.05	.05	.05	.055	.052	.06
Depth of head	.18	.19	.175	.17	.185	.175	.185	.18	.18	.18
Height of dorsal	.18	.19	.18	.18	.19	.18	.185	.205	.205	.20
Height of anal	.18	.185	.18	.18	.18	.18	.18	.185	.17	.18
Length of pectoral	.19	.20	.195	.19	.185	.19	.19	.20	.19	.20
Length of ventral	.16	.155	.155	.15	.145	.15	.155	.16	.15	.16
Length of caudal	.25	.27	.26	.255	.26	.265	.26	.27	.28	.26
Dorsal rays	15	15	14	14	14	14	13	14	14	13
Scales of lateral line	70	66	66	65	64	64	64	66	64	66
Scales above lateral line	13	13	13	14	13	13	13	14	14	14
Scales before dorsal	33	32	33	36	31	34	34	37	32	33

Catostomus warnerensis, new species.

The catostomid found in the Warner basin appears to be related to both *C. tahoensis* of the Lahontan system and *C. catostomus* of wide distribution to the north and east. Although resembling each very closely, it can not as we now recognize those species be identified with either. The Warner form has larger scales, there being fewer in the lateral line (73 to 79 compared with 79 to 104), smaller eyes, and a smaller mouth with narrower lower lips. Its affinities are also with the very similar small-scaled species *C. microps*[a] of the Sacramento and *C. rimiculus* of the Klamath. It appears, however, to have larger scales than either of these forms. It differs from *C. microps* also in having a larger eye.

Cope[b] identified *C. warnerensis* with the species common to the basins of the Lahontan system, but it appears no more closely to resemble that form than it does *C. catostomus*. As here defined the species is found only in the Warner basin. It inhabits the larger streams tributary to the lake, appearing

[a] Rutter, Cloudsley, Bulletin U. S. Bureau of Fisheries, vol. XXVII, 1907, p. 120.

[b] Cope, E. D., Proceedings Academy Natural Sciences, Philadelphia, 1883, p. 152. The difference in the size of the scales, as shown by examples from the two basins, was noted by this author: "Pyramid Lake; scales, 14-89-14." "Warner Lake; scales, 16-83-15."

in the latter wherever the water is not too strongly impregnated with mineral salts. It has not been found in Warner Creek above the falls.

Description of type no. 55597 U. S. National Museum, from Warner Creek, near Adel, Lake County, Oreg.: Total length, 296 mm. Head, 3.8 in length to base of caudal; depth, 4.5; depth of caudal peduncle, 3.1 in head; snout, 2.1; eye, 8.3; dorsal, 10; anal, 7; scales in lateral line, 79; between occiput and insertion of dorsal, 43; between lateral line and middle of back, 19; between lateral line and insertion of anal, 14. Eye midway between tip of snout and edge of opercle. Inner portion of lip with a scarcely evident horny sheath, much less conspicuous than that of *C. catostomus;* upper lip with 3 or 4 rows of papillæ, the median ones largest; lower lip with 7 or more rows, smaller papillæ frequently being wedged in between the larger ones; cleft of mandibular lobe not complete, a space covered by 2 or more rows of papillæ intervening. Length of base of dorsal equal to height of fin. Anal rather acutely rounded, reaching base of caudal when depressed. Origin of ventrals below base of fourth or fifth dorsal ray; fins when depressed falling considerably short of anal opening. Pectorals rounded, their tips reaching two-

FIG. 2.—Catostomus warnerensis, new species. Type.

thirds of distance between their bases and the ventrals. Caudal with a shallow notch, the lobes rounded. Peritoneum dusky. Color dark above, light below; the dark and light areas separated on a lateral line passing just below middle of sides. In life the dusky portion is greenish black, having in places a slight brassy sheen; the light ventral parts creamy white. Fins dusky, the lower ones lighter than the others.

In some examples there are 5 or 6 indefinite rows of papillæ on the upper lip and 8 or more on the lower. Small specimens have the boundaries of the light and dark areas less sharply defined. In individuals 60 or 70 mm. long the color of the darker parts is broken up into spots of irregular shape and size.

The appended table of measurements will indicate other slight individual variations. Similar measurements of examples of *C. tahoensis* are also given.

Represented by specimens from Warner Creek, sloughs south of Warner Creek, and from Honey Creek.

MEASUREMENTS OF SPECIMENS OF CATOSTOMUS WARNERENSIS FROM WARNER CREEK, LAKE COUNTY, OREG.

Length of body........mm..	245	152	145	140	124	74	71	61	54	57	56	[illegible]
Length of head	.26	.26	.24	.25	.245	.26	.26	.27	.26	.26	.27	.27
Snout to dorsal	.54	.52	.52	.53	.51	.515	.52	.515	.51	.51	.52	[illegible]
Snout to ventral	.585	.57	.55	.585	.565	.575	.55	.59	.56	.56	.58	[illegible]
Depth of caudal peduncle	.07	.09	.09	.09	.095	.10	.09	.09	.09	.10	.09	[illegible]
Length of snout	.12	.12	.11	.105	.11	.115	.11	.105	.11	.105	.105	[illegible]
Width of lower lip	.033	.03	.03	.04	.037	.033	.03	.03	.03	.03	.03	[illegible]
Diameter of eye	.033	.032	.035	.04	.038	.045	.045	.055	.05	.05	.065	[illegible]
Height of dorsal	.16	.18	.17	.18	.185	.185	.20	.22	.20	.21	.20	[illegible]
Height of anal	.205	.18	.19	.21	.20	.165	.17	.175	.16	.17	.18	[illegible]
Length of pectoral	.20	.19	.185	.20	.19	.18	.18	.22	.20	.20	.205	[illegible]
Length of ventral	.16	.14	.14	.14	.15	.14	.145	.16	.15	.15	.16	[illegible]
Length of caudal	.20	.22	.21	.23	.21	.22	.23	.25	.24	.24	.25	[illegible]
Dorsal rays	10	10	10	11	10	10	11	10	10	10	10	10
Anal rays	7	7	7	7	7	7	7	7	7	7	7	7
Scales of lateral line	79	79	76	77	76	75	75	73	75	74	76	[illegible]
Scales above lateral line	19	19	17	18	17	17	18	16	17	17	16	[illegible]
Scales before dorsal	43	38	39	41	38	38	37	37	40	39	37	42

MEASUREMENTS OF SPECIMENS OF CATOSTOMUS TAHOENSIS.

From Warm Springs Creek, Summit, Nev.

Length of body........mm..	166	152	145	140	136	123	133	116
Length head	.27	.24	.245	.24	.25	.24	.23	.25
Snout to dorsal	.53	.515	.52	.52	.525	.51	.51	.51
Snout to ventral	.60	.59	.58	.57	.59	.59	.58	.585
Depth caudal peduncle	.085	.095	.095	.09	.095	.095	.085	.095
Length snout	.115	.11	.11	.105	.115	.12	.10	.125
Width lower lip	.052	.053	.06	.05	.05	.045	.05	.05
Diameter eye	.045	.05	.043	.04	.045	.05	.045	.045
Height dorsal	.16	.17	.17	.165	.165	.16	.17	.165
Height anal	.215	.20	.19	.185	.21	.19	.195	.195
Length pectoral	.195	.18	.18	.18	.195	.19	.17	.20
Length ventral	.15	.15	.15	.13	.14	.145	.13	.14
Length caudal	.24	.21	.21	.20	.23	.225	.21	.225
Dorsal rays	11	11	11	10	11	11	11	11
Anal rays	7	7	7	7	7	7	7	7
Scales lateral line	79	83	79	79	84	94	93	....
Scales above lateral line	17	18	15	18	19	18	16	17
Scales before dorsal	41	41	42	47	44	44	48	44

From Lake Tahoe, Cal.

Length of body........mm..	215	220	208	Height anal	.18	.20	.21
Length head	.25	.22	.25	Length pectoral	.175	.19	.19
Snout to dorsal	.53	.515	.54	Length ventral	.14	.14	.14
Snout to ventral	.62	.62	.62	Length caudal	.195	.215	.22
Depth caudal peduncle	.09	.09	.095	Dorsal rays	10	11	12
Length snout	.12	.11	.12	Anal rays	7	7	7
Width lower lip	.045	.04	.04	Scales lateral line	88	90	90
Diameter eye	.045	.04	.04	Scales above lateral line	20	19	18
Height dorsal	.155	.16	.17	Scales before dorsal	44	43	47

Catostomus catostomus (Forster).

Examples from Silvies River at Burns and from Silver River near Riley are very similar to specimens from the Columbia. The Harney specimens appear to have slightly larger scales, however, there being from 83 to 93 rows in the lateral line, while individuals from Little Wood River and Ross Fork, Idaho, have from 88 to 96. Others are recorded as having 90 to 104.[a]

[a] Gilbert & Evermann, Bulletin U. S. Fish Commission, vol. XIV, 1894, p. 189.

MEASUREMENTS OF SPECIMENS OF CATOSTOMUS CATOSTOMUS.

From Silvies River, Burns, Oreg.

Length of body .... mm..	178	229	Height anal	.185	.20
Length head	.215	.215	Length pectoral	.18	.19
Snout to dorsal	.51	.51	Length ventral	.15	.17
Snout to ventral	.575	.555	Length caudal	.23	.24
Depth caudal peduncle	.075	.075	Dorsal rays	11	11
Length snout	.11	.105	Anal rays	7	7
Width lower lip	.053	.05	Scales lateral line	93	93
Diameter eye	.037	.035	Scales above lateral line	19	21
Height dorsal	.18	.175	Scales before dorsal	49	46

From Silver River, Harney County, Oreg.

Length of body .... mm..	221	121	112	118	.115	52	55
Length head	.22	.24	.235	.22	.23	.26	.25
Snout to dorsal	.525	.54	.52	.52	.525	.55	.54
Snout to ventral	.585	.59	.59	.56	.59	.61	.59
Depth caudal peduncle	.085	.085	.08	.08	.08	.085	.085
Length snout	.105	.11	.11	.10	.115	.116	.11
Width lower lip	.055	.05	.055	.05	.05	.06	.055
Diameter eye	.035	.045	.04	.043	.04	.055	.05
Height dorsal	.16	.19	.175	.18	.185	.21	.20
Height anal	.22	.175	.20	.19	.175	.17	.17
Length pectoral	.20	.19	.195	.20	.19	.19	.20
Length ventral	.165	.16	.165	.16	.155	.16	.16
Length caudal	.23	.23	.22	.24	.23	.26	.27
Dorsal rays	11	11	11	12	11	11	11
Anal rays	7	7	7	7	7	7	7
Scales lateral line	83	86	91	89	84	88	84
Scales above lateral line	18	20	18	19	18	19	19
Scales before dorsal	45	45	44	52	46	51	45

Acrocheilus alutaceus (Agassiz & Pickering).

Silvies River near Burns; 8 specimens about 100 mm. long.

Mylopharodon conocephalus (Baird & Girard).

Pitt River near Alturas, and near Canby, Big Valley. The former, 3 in number, measure about 350 mm. in length. The fins were bright salmon red. Scales in lateral line 73 to 77, above lateral line 19 to 20, between occiput and dorsal 49 to 54, dorsal 8, anal 8.

Ptychocheilus oregonensis (Richardson).

Specimens of *Ptychocheilus* from the Malheur basin are apparently identical with *P. oregonensis* of the Columbia. A comparison of examples from Silvies River and from the Willamette shows that the former have somewhat longer fins. A few individuals from Hangmans Creek, Washington, and from Boise River, Idaho, are intermediate in this respect between the Silvies and Willamette specimens.

MEASUREMENTS OF SPECIMENS OF PTYCHOCHEILUS OREGONENSIS.

From Silvies River near Burns, Oreg.

Length of body .... mm..	218	203	222	191	219	183	153	158	145	148	99	109	101	98	96
Length head	.285	.275	.287	.28	.27	.273	.29	.28	.29	.27	.275	.29	.29	.28	.285
Depth body	.24	.22	.245	.235	.225	.245	.245	.225	.22	.22	.245	.21	.22	.21	.22
Snout to dorsal	.60	.575	.595	.585	.575	.58	.58	.595	.60	.58	.597	.59	.59	.59	.59
Snout to ventral	.56	.565	.555	.56	.553	.54	.57	.56	.58	.57	.57	.54	.565	.56	.55
Length snout	.105	.105	.10	.105	.095	.10	.10	.105	.105	.097	.10	.10	.10	.10	.10
Length maxillary	.115	.11	.12	.115	.11	.112	.117	.115	.12	.11	.11	.11	.11	.115	.105
Diameter eye	.043	.045	.045	.046	.042	.045	.05	.045	.05	.05	.065	.055	.06	.06	.06
Interorbital width	.075	.08	.08	.08	.075	.08	.08	.08	.08	.08	.08	.08	.085	.085	.08
Height dorsal	.17	.17	.175	.175	.17	.175	.18	.19	.185	.183	.20	.18	.195	.20	.185
Height anal	.175	.16	.155	.155	.16	.155	.17	.17	.162	.17	.165	.155	.18	.17	.17
Length pectoral	.21	.195	.21	.19	.20	.185	.17	.185	.17	.18	.17	.16	.18	.17	.175
Length ventral	.155	.155	.15	.15	.14	.145	.15	.145	.135	.15	.15	.14	.15	.15	.145
Length caudal	.26	.27	.255	.255	.25	.25	.27	.26	.28	.265	.285	.27	.28	.28	.28
Dorsal rays	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Anal rays	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Scales lateral line	69	68	69	69	70	74	74	70	73	74	75	68	69	71	70
Scales before dorsal	49	46	50	48	50	49	47	50	50	51	54	52	53	53	51
Scales above lateral line	19	19	17	19	18	48	18	19	18	20	19	17	20	17	18

Measurements of Specimens of Ptychocheilus oregonensis—Continued.

From Willamette River, near Corvallis, Oreg.

Length of body.........mm..	255	280	305	231	225	255	241	260	247	[illegible]
Length head....	.28	.29	285	29	27	.295	275	28	285	285
Depth body....	21	.215	215	22	225	22	.22	215	21	205
Snout to dorsal....	555	58	59	60	56	59	58	58	58	575
Snout to ventral....	525	55	55	57	55	58	55	565	57	545
Length snout....	095	.10	10	105	11	09	105	10	10	105
Length maxillary....	11	12	12	12	11	12	115	12	12	12
Diameter eye....	04	045	04	.05	045	045	045	045	.045	045
Interorbital width....	.08	.075	08	08	08	.085	.08	085	09	.08
Height dorsal....	16	15	.15	175	165	155	.165	165	.165	.17
Height anal....	.15	.15	.155	.16	15	14	16	145	15	155
Length pectoral....	16	175	15	19	175	16	.18	16	175	.185
Length ventral....	.14	.13	.12	14	13	.12	14	.13	13	.14
Length caudal....	24	235	[illegible]	.24	.24	.235	.24	.23	225	24
Dorsal rays....	9	9	9	9	9	9	9	9	9	9
Anal rays....	8	8	8	8	8	8	8	8	8	8
Scales lateral line....	69	69	68	73	69	69	70	71	75	70
Scales before dorsal....	53	54	48	49	50	47	53	49	50	48
Scales above lateral line....	18	18	17	17	18	17	17	17	18	17

Ptychocheilus grandis (Ayres).

Pitt River, near Alturas, and in Big Valley.

Leuciscus balteatus (Richardson).

Warm Springs, Silver Creek, and Silvies River.

Specimens collected at Warm Springs and at Silver Creek were brilliantly colored, especially the former, a description of which follows: Dorsal surface of body deep green; a narrow, diffuse, brassy stripe extending from eye along lateral line, falling below it posteriorly, forming a ventral border to the greenish dorsal area; an indistinct dark greenish stripe extending from eye along the side just below the brassy band; breast and abdomen silvery; sides just below greenish band bright red; snout anterior to eye greenish; cheeks below eye and opercle brassy; fins golden. Immedately after death the greenish dorsal area turns to a steel blue.

In this connection a color description from life made at Cow Creek, a tributary of the Umpqua River, may be of interest: Dorsal surface dark, dull olive; a narrow, sharply defined yellowish orange band, one scale wide, extending from posterior edge of orbit to middle of caudal peduncle, dividing the olive area posteriorly so that a narrow space of the latter color extends below the yellow stripe; breast and abdomen silvery white; sides below yellow stripe orange, the upper edges of the orange area deeply suffused with red; snout, upper part of head, olive; a bright red patch below eye, separated from the latter by a narrow olive area; opercles brassy; fins yellowish.

The following table shows the number of rays in the anal fins of 124 examples.[a] Attention is directed to the fact that Warm Springs and Silver Creek are closely connected, while Silvies River is isolated from both.

Anal fin rays.	Warm Springs.	Silver Creek.	Silvies River.
	Specimens.	*Specimens.*	*Specimens.*
9.	....	2	....
10.	7	8	....
11.	20	30	....
12.	4	18	2
13.	1	1	7
14.	....	....	8
15.	....	....	13
16.	....	....	3

[a] For a discussion of the variation in the number of anal fin rays of *L. balteatus* see Gilbert and Evermann, Bulletin U. S. Fish Commission, vol. XIV, 1894, p. 196.

Rutilus thalassinus (Cope).

Cottonwood Creek, Oreg.; Muddy Creek and Goose Lake, Lake County, Oreg.; Pitt River near Alturas; Pitt River near Canby and Pitt River in Big Valley, Cal.

Cope [a] recognized two closely related species of *Rutilus* (*Myloleucus*) from Goose Lake, both of which are no doubt referable to the same form which he describes under the name *Myloleucus thalassinus*. This species is not to be confused with *Rutilus symmetricus* occurring in the same basin, nor should it be identified with the *Myloleucus parovanus* of Cope [b] from Beaver River, Utah.

R. thalassinus may be distinguished from each of the species of *Rutilus* here described by its longer fins. It further differs from *R. bicolor* in having a larger head, a more posterior location of the dorsal fin, and in usually possessing one more dorsal ray; from *R. oregonensis* in having larger scales, there being fewer in the lateral series, in the series before the dorsal fin and in those above the lateral line, and also in having one more dorsal ray; from *R. columbianus* in having a greater number of scales in the lateral series and a lesser number between occiput and dorsal fin. These differences are set forth in greater detail in the tabulated comparisons of the four forms, page 94 et seq.

As at present understood, this species is confined in its distribution to the Sacramento basin, this being the first account of its occurrence beyond the confines of Goose Lake. It is to be searched for in bayous, deep quiet pools, and sluggish streams.

MEASUREMENTS OF SPECIMENS OF RUTILUS THALASSINUS FROM PITT RIVER NEAR CANBY, LASSEN COUNTY, CAL.

Length of body.....mm..	150	139	123	125	100	106	116	103	93	101
Length head	.29	.28	.28	.27	.26	.29	.27	.28	.27	.28
Snout to occiput	.235	.22	.22	.22	.21	.225	.21	.22	.21	.22
Snout to dorsal	.58	.59	.57	.58	.56	.59	.58	.58	.60	.58
Snout to ventral	.57	.57	.595	.58	.54	.59	.55	.58	.58	.57
Depth body	.29	.30	.31	.30	.28	.31	.28	.30	.28	.30
Depth caudal peduncle	.12	.125	.12	.13	.12	.125	.12	.13	.12	.125
Length snout	.09	.085	.09	.08	.085	.09	.08	.09	.08	.085
Length maxillary	.09	.085	.085	.08	.08	.09	.08	.09	.08	.085
Diameter eye	.06	.06	.055	.06	.055	.055	.06	.06	.06	.06
Interorbital width	.10	.10	.10	.10	.09	.10	.10	.09	.10	.10
Height dorsal	.255	.22	.22	.22	.21	.23	.21	.21	.21	.23
Height anal	.20	.18	.18	.16	.185	.19	.18	.18	.17	.19
Length pectoral	.21	.20	.19	.19	.20	.21	.18	.20	.18	.20
Length ventral	.20	.165	.185	.16	.175	.18	.16	.18	.17	.18
Length caudal	.32	.30	.31	.28	.28	.32	.30	.30	.28	.29
Scales lateral line	47	49	52	51	50	51	49	51	48	51
Scales above lateral line	11	11	12	13	11	11	11	11	11	11
Scales below lateral line	6	5	6	6	6	6	6	6	7	5
Scales before dorsal	25	27	25	27	26	25	25	26	27	25
Dorsal rays	9	9	9	9	9	9	9	9	9	9
Anal rays	8	8	8	8	8	9	8	8	8	8

Length of body.....mm..	99	86	86	82	84	78	75	106	137
Length head	.28	.29	.28	.29	.28	.28	.29	.28	.28
Snout to occiput	.25	.23	.21	.23	.22	.24	.24	.22	.22
Snout to dorsal	.59	.59	.57	.58	.57	.59	.59	.58	.57
Snout to ventral	.58	.56	.56	.56	.57	.56	.60	.57	.58
Depth body	.30	.30	.30	.29	.28	.27	.30	.29	.31
Depth caudal peduncle	.13	.13	.13	.13	.115	.12	.13	.13	.135
Length snout	.08	.095	.08	.085	.08	.08	.09	.09	.085
Length maxillary	.085	.095	.08	.09	.08	.08	.09	.08	.08
Diameter eye	.06	.07	.06	.065	.065	.075	.07	.06	.055
Interorbital width	.10	.10	.10	.10	.09	.10	.10	.10	.10
Height dorsal	.23	.24	.23	.23	.21	.22	.26	.225	.21
Height anal	.19	.19	.18	.19	.18	.18	.19	.18	.18
Length pectoral	.20	.22	.20	.20	.18	.19	.18	.19	.185
Length ventral	.18	.19	.19	.18	.16	.18	.175	.17	.175
Length caudal	.33	.33	.32	.33	.31	.32	.33	.31	.31
Scales lateral line	47	49	47	50	50	47	46	46	51
Scales above lateral line	11	12	12	11	11	11	11	11	11
Scales below lateral line	5	6	6	6	5	5	6	6	6
Scales before dorsal	24	26	26	25	26	26	23	25	25
Dorsal rays	9	9	9	9	9	9	9	9	9
Anal rays	9	9	8	8	8	8	8	8	9

[a] Cope, E. D., Proceedings Academy Natural Sciences Philadelphia, 1883, p. 143-144. Cope's supposition that he had in hand 2 distinct species was probably due to the poor preservation of his specimens. He says (p. 139): "I fished for a day with hook and line without success, but procured a good collection of fishes by another method. I found numerous specimens both fresh and dry, which had been dropped by fishing birds on or near the shore."

[b] Cope, E. D., Proceedings American Philosophical Society, Philadelphia, 1874, p. 136.

Rutilus oregonensis, new species.

This name is here applied to a distinct form found in the isolated lake basins of southeastern Oregon. It is very similar to closely related forms found in the Sacramento, Klamath, and Columbia systems, but differs widely from *R. olivaceus* of the Lahontan system in important dental characters, the latter species having the pharyngeal teeth 5–5.

It differs from the more nearly related forms as follows: From *R. thalassinus* in having shorter fins, a greater number of scales in the lateral line, in the series before dorsal fin, and above lateral line, and also in usually having one less dorsal ray; from *R. bicolor* in having generally a larger head, smaller scales, there being a greater number in the lateral series, between occiput and dorsal fin and above the lateral line; from *R. columbianus* in having smaller scales and in other minor points. These differences are shown in greater detail in the tabulated comparisons of the four forms, page 94 et seq.

Description of type no. 55596, U. S. National Museum, from XL Spring, Abert Lake, Oregon: Total length 202 mm. Head 3.6 in length to base of caudal; depth 3.6; depth caudal peduncle 9; depth head at occiput 5; length snout 3.3 in head; maxillary 3.7; diameter eye 6.1; width space between eyes 3; height dorsal 1.8; anal 2.2; length pectoral 1.6; ventral 2; caudal 1.3; scales lateral line 52; above lateral line 13; between lateral line and origin of ventral 8; between occiput and origin of dorsal 27.

FIG. 3.—Rutilus oregonensis, new species. Type.

Body deep and heavy, the dorsal contour with an abrupt elevation at occiput. Mouth very oblique; maxillary extending to a perpendicular through nostril, not nearly reaching anterior border of orbit. Gillrakers on first arch 14, very short, not equal to half the diameter of pupil, acutely pointed. Teeth (from cotypes) 4–5, short and strong, a narrow grinding surface present, tips of smaller ones somewhat hooked. Peritoneum almost black. Intestinal canal very short, its length equal to about $1\frac{1}{4}$ times total length of fish. Lateral line complete, somewhat decurved immediately behind head. Dorsal placed directly above ventrals, the length of its base equal to height of third ray, the free edge straight. Anal shaped like the dorsal, length of base equal to height of fourth ray. Pectorals and ventrals bluntly rounded, the latter not reaching anal opening; notch of caudal broadly rounded. Color in spirits very dark, even the ventral surface being decidedly dusky; edges of scales being much darker than their centers. In life the color is dark olive, some examples having a greener tint, the fins with somewhat darker edges.

Smaller examples do not have a prominent post-occipital hump, the elevation growing more pronounced with age. The young generally have the fins slightly longer and the caudal more acutely notched. In other localities the specimens are often lighter in color, the variation apparently coinciding with the immediate surroundings. In lighter-colored examples the peritoneum is also less dusky. Sexual differences are not striking, the males generally having slightly longer fins. Females appear to be much more abundant than males.

Warner Creek and sloughs south of Warner Creek; Honey Creek; Warner Lake north of Honey Creek; Chewaucan River, Paisley; Chewaucan River, near mouth; XL Spring, Abert Lake; spring, Alkali Lake; spring, Summer Lake Post Office; Ana River; springs at source of Ana River; Silver Lake; Silver Creek near mouth; Bridge Creek; Silver Creek near Silvercreek Post-Office; Buck Creek.

The rather extensive table of comparative measurements which is here inserted shows that while examples from the different lake basins may possibly show slight differences among themselves, they all agree in being differentiated in a measureable way from their representatives in the neighboring systems.

MEASUREMENTS OF SPECIMENS OF RUTILUS OREGONENSIS FROM ISOLATED BASINS OF THE OREGON LAKE SYSTEM.

From XL Spring, Abert Lake.

Length of body.....mm..	106	138	120	125	103	115	97	91	101	112
Length head	.28	.26	.285	.285	.28	.28	.29	.28	.29	.28
Snout to occiput	.21	.21	.22	.22	.22	.21	.22	.215	.21	.21
Snout to dorsal	.56	.56	.58	.58	.57	.56	.58	.54	.55	.55
Snout to ventral	.56	.55	.58	.56	.54	.54	.54	.55	.56	.54
Depth body	.265	.29	.29	.29	.27	.27	.26	.29	.29	.27
Depth caudal peduncle	.11	.12	.12	.125	.125	.12	.12	.13	.13	.13
Length snout	.08	.08	.085	.09	.09	.08	.08	.08	.09	.08
Length maxillary	.08	.08	.08	.085	.08	.08	.08	.08	.09	.08
Diameter eye	.045	.05	.055	.055	.06	.055	.065	.06	.06	.055
Interorbital width	.09	.09	.10	.10	.09	.10	.10	.09	.10	.09
Height dorsal	.17	.17	.18	.19	.19	.19	.18	.20	.19	.19
Height anal	.14	.14	.14	.15	.15	.135	.15	.16	.16	.155
Length pectoral	.17	.17	.175	.19	.19	.17	.18	.23	.19	.20
Length ventral	.15	.14	.15	.155	.17	.155	.155	.18	.16	.18
Length caudal	.25	.24	.24	.25	.25	.26	.26	.28	.25	.26
Scales lateral line	59	57	55	55	53	57	56	55	57	55
Scales above lateral line	12	13	13	13	14	13	12	13	13	13
Scales below lateral line	8	7	8	7	7	7	7	8	7	7
Scales before dorsal	31	29	31	30	29	32	31	28	28	31
Dorsal rays	8	9	8	8	8	7	8	8	8	9
Anal rays	8	8	8	8	8	7	8	8	8	8
Length of body.....mm..	95	104	110	101	107	140	110	106	132	120
Length head	.27	.28	.27	.29	.28	.265	.28	.29	.29	.27
Snout to occiput	.21	.22	.22	.21	.22	.215	.21	.22	.22	.21
Snout to dorsal	.555	.54	.555	.56	.56	.58	.58	.57	.57	.55
Snout to ventral	.555	.55	.54	.55	.54	.57	.55	.57	.57	.545
Depth body	.25	.28	.29	.29	.27	.265	.28	.30	.27	.26
Depth caudal peduncle	.11	.12	.12	.115	.12	.125	.12	.12	.125	.12
Length snout	.08	.09	.08	.09	.08	.08	.09	.09	.08	.085
Length maxillary	.08	.09	.08	.09	.075	.08	.08	.085	.08	.09
Diameter eye	.055	.06	.055	.055	.06	.055	.055	.06	.055	.055
Interorbital width	.09	.10	.09	.10	.095	.09	.095	.10	.095	.085
Height dorsal	.18	.19	.17	.18	.15	.17	.165	.19	.17	.165
Height anal	.15	.16	.135	.15	.135	.145	.14	.15	.135	.13
Length pectoral	.18	.20	.18	.18	.16	.17	.17	.195	.19	.17
Length ventral	.15	.16	.15	.15	.13	.14	.14	.17	.15	.135
Length caudal	.26	.25	.26	.25	.23	.24	.24	.27	.24	.24
Scales lateral line	55	56	55	54	56	55	54	51	54	59
Scales above lateral line	12	13	13	14	11	12	13	12	14	13
Scales below lateral line	9	8	7	7	7	7	8	7	7	7
Scales before dorsal	30	30	28	30	30	30	29	30	30	29
Dorsal rays	8	8	9	8	8	9	8	8	8	8
Anal rays	8	8	8	8	8	8	7	8	8	8

MEASUREMENTS OF SPECIMENS OF RUTILUS OREGONENSIS FROM ISOLATED BASINS OF THE OREGON LAKE SYSTEM—Continued.

From Chewaucan River, Paisley.

Length of body......mm..	76	84	107	101	92	84	92	133	111
Length head	.28	.26	.27	.27	.27	.25	.27	.28	.255
Snout to occiput	.21	.195	.21	.21	.20	.18	.21	.20	.20
Snout to dorsal	.57	.55	.555	.58	.58	.55	.555	.56	.55
Snout to ventral	.57	.53	.54	.57	.55	.54	.555	.56	.55
Depth of body	.26	.29	.28	.28	.28	.27	.28	.265	.255
Depth caudal peduncle	.125	.13	.13	.13	.12	.12	.13	.12	.115
Length of snout	.08	.075	.08	.08	.08	.075	.085	.09	.07
Length maxillary	.08	.075	.08	.08	.08	.07	.08	.08	.07
Diameter eye	.06	.055	.05	.05	.05	.055	.055	.045	.05
Interorbital width	.10	.10	.10	.10	.10	.095	.09	.095	.085
Height dorsal	.21	.20	.21	.19	.20	.20	.19	....	.19
Height anal	.17	.15	.17	.15	.155	.16	.15	.14	.145
Length pectoral	.175	.19	.18	.18	.18	.17	.16	.165	.165
Length ventral	.17	.145	.17	.16	.16	.16	.15	.16	.15
Length caudal	.27	.25	.26	.24	.26	.25	.24	.24	.24
Scales lateral line	55	53	54	49	52	53	52	57	57
Scales above lateral line	12	12	12	11	13	12	12	13	12
Scales below lateral line	7	7	7	6	7	7	7	7	7
Scales before dorsal	27	28	29	30	31	29	30	29	31
Dorsal rays	8	8	8	8	8	8	8	....	8
Anal rays	7	7	7	8	8	8	8	8	8

Length of body......mm..	78	91	94	96	94	108	96	111
Length head	.255	.27	.27	.26	.26	.26	.275	.29
Snout to occiput	.20	.21	.21	.195	.19	.20	.20	.22
Snout to dorsal	.54	.55	.56	.56	.55	.57	.58	.57
Snout to ventral	.55	.54	.55	.54	.54	.55	.57	.56
Depth of body	.26	.28	.28	.27	.28	.27	.31	.28
Depth caudal peduncle	.12	.13	.13	.12	.13	.12	.135	.12
Length snout	.075	.07	.08	.07	.08	.075	.075	.08
Length maxillary	.075	.065	.08	.07	.075	.07	.075	.08
Diameter eye	.055	.055	.05	.05	.05	.05	.055	.05
Interorbital width	.09	.09	.10	.09	.09	.09	.10	.095
Height dorsal	.21	.21	.20	.18	.20	.19	.20	.19
Height anal	.16	.16	.165	.14	.15	.14	.15	.15
Length pectoral	.20	.22	.19	.16	.18	.18	.17	.175
Length ventral	.16	.17	.16	.15	.16	.15	.15	.15
Length caudal	.25	.26	.26	.22	.24	.23	.25	.24
Scales lateral line	55	52	54	51	59	55	51	55
Scales above lateral line	12	12	12	12	12	12	12	12
Scales below lateral line	7	7	6	7	8	7	7	7
Scales before dorsal	30	28	31	27	32	29	29	28
Dorsal rays	8	8	8	8	8	8	8	8
Anal rays	7	7	7	7	8	8	8	7

From Ana River, Summer Lake.

Length of body......mm..	128	72	89	84	84	96	96	80	73	70
Length head	.27	.28	.26	.26	.28	.28	.27	.28	.28	.26
Snout to occiput	.23	.22	.21	.21	.23	.22	.21	.22	.23	.21
Snout to dorsal	.58	.56	.555	.56	.58	.58	.58	.56	.58	.54
Snout to ventral	.56	.555	.56	.56	.58	.58	.56	.57	.58	.53
Depth body	.28	.27	.27	.28	.29	.28	.265	.27	.27	.26
Depth caudal peduncle	.12	.125	.12	.13	.12	.13	.12	.125	.13	.11
Length snout	.095	.08	.085	.08	.095	.095	.085	.09	.09	.085
Length maxillary	.08	.08	.08	.07	.08	.09	.085	.08	.085	.075
Diameter eye	.055	.07	.055	.06	.06	.055	.055	.06	.06	.055
Interorbital width	.10	.10	.09	.10	.105	.10	.10	.10	.10	.09
Height dorsal	.17	.19	.195	.20	.20	.20	.17	.20	.18	.19
Height anal	.15	.15	.15	.15	.16	.18	.15	.16	.15	.13
Length pectoral	.17	.17	.20	.20	.18	.18	.17	.18	.15	.16
Length ventral	.14	.15	.16	.16	.14	.16	.13	.14	.14	.13
Length caudal	.23	.26	.24	.25	.25	.26	.24	.26	.23	.24
Scales lateral line	53	52	57	56	52	53	55	56	57	57
Scales above lateral line	12	12	12	13	12	12	12	12	13	12
Scales below lateral line	6	7	7	7	8	7	7	7	7	6
Scales before dorsal	28	31	31	32	30	31	29	28	28	31
Dorsal rays	8	8	8	8	8	8	8	9	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7

MEASUREMENTS OF SPECIMENS OF RUTILUS OREGONENSIS FROM ISOLATED BASINS OF THE OREGON LAKE SYSTEM—Continued.

From Ana River, Summer Lake—Continued.

Length of body ....mm..	68	76	72	79	77	79	75	73	72	73
Length head	.28	.275	.27	.26	.28	.27	.27	.27	.28	.285
Snout to occiput	.23	.22	.22	.21	.22	.22	.215	.22	.21	.23
Snout to dorsal	.55	.58	.59	.56	.55	.56	.57	.56	.57	.57
Snout to ventral	.56	.57	.57	.56	.56	.55	.56	.55	.57	.57
Depth body	.27	.28	.28	.26	.27	.28	.26	.27	.28	.27
Depth caudal peduncle	.13	.13	.12	.12	.125	.13	.13	.12	.13	.125
Length snout	.09	.08	.09	.095	.085	.085	.08	.09	.08	.085
Length maxillary	.08	.085	.08	.07	.08	.08	.08	.085	.08	.08
Diameter eye	.06	.065	.065	.06	.06	.06	.06	.065	.06	.06
Interorbital width	.10	.10	.10	.085	.10	.09	.10	.095	.10	.10
Height dorsal	.21	.20	.18	.20	.19	.21	.20	.19	.20	.20
Height anal	.16	.14	.14	.13	.13	.16	.14	.15	.15	.14
Length pectoral	.20	.17	.18	.18	.17	.21	.17	.21	.16	.17
Length ventral	.15	.13	.16	.15	.14	.17	.15	.16	.15	.15
Length caudal	.27	.25	.27	.23	.25	.26	.25	.24	.24	.26
Scales lateral line	52	56	57	53	55	56	54	52	54	55
Scales above lateral line	12	13	13	13	14	13	12	11	12	11
Scales below lateral line	6	7	7	7	8	7	7	7	7	6
Scales before dorsal	31	32	31	30	33	31	31	28	30	29
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	7	8	7	7	7	7	8	7	7

From Bridge Creek, Silver Lake.

Length of body ....mm..	88	66	71	70	75	80	72	93	89	83
Length head	.27	.28	.29	.28	.26	.28	.27	.27	.27	.28
Snout to occiput	.22	.26	.22	.22	.21	.22	.20	.205	.21	.22
Snout to dorsal	.56	.57	.58	.55	.54	.55	.53	.54	.57	.56
Snout to ventral	.55	.55	.57	.55	.535	.56	.53	.54	.53	.55
Depth body	.26	.27	.28	.26	.27	.27	.245	.27	.26	.27
Depth caudal peduncle	.115	.12	.125	.12	.115	.13	.115	.12	.12	.12
Length snout	.08	.08	.085	.08	.08	.085	.08	.08	.08	.08
Length maxillary	.08	.08	.085	.08	.07	.08	.08	.07	.08	.08
Diameter eye	.06	.07	.07	.065	.06	.065	.07	.055	.06	.06
Interorbital width	.09	.09	.095	.09	.09	.09	.09	.10	.09	.09
Height dorsal	.18	.21	.20	.20	.20	.22	.20	.19	.20	.19
Height anal	.14	.16	.14	.16	.15	.17	.17	.14	.15	.14
Length pectoral	.17	.18	.185	.21	.17	.20	.19	.15	.17	.16
Length ventral	.15	.16	.15	.15	.15	.17	.16	.14	.15	.14
Length caudal	.25	.28	.26	.25	.26	.28	.27	.25	.25	.25
Scales lateral line	51	49	49	54	55	52	55	51	55	52
Scales above lateral line	11	11	11	12	12	11	11	11	12	11
Scales below lateral line	6	6	6	6	6	6	6	7	6	6
Scales before dorsal	26	27	25	28	29	26	25	25	25	27
Dorsal rays	9	8	8	9	8	9	8	9	8	8
Anal rays	8	7	7	7	7	7	7	8	7	8

Length of body ....mm..	76	78	70	71	69	68	67	70	65	67
Length head	.28	.29	.28	.27	.28	.28	.28	.27	.28	.27
Snout to occiput	.22	.215	.22	.21	.215	.22	.22	.22	.22	.20
Snout to dorsal	.55	.56	.57	.56	.54	.56	.56	.55	.55	.54
Snout to ventral	.56	.57	.57	.54	.56	.55	.55	.55	.55	.54
Depth body	.28	.27	.26	.26	.28	.25	.26	.26	.26	.26
Depth caudal peduncle	.12	.12	.12	.11	.13	.125	.13	.12	.13	.13
Length snout	.08	.08	.08	.08	.08	.08	.08	.085	.09	.075
Length maxillary	.085	.08	.08	.075	.08	.075	.08	.085	.08	.08
Diameter eye	.06	.06	.07	.06	.06	.07	.08	.07	.075	.065
Interorbital width	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
Height dorsal	.22	.20	.20	.19	.20	.21	.23	.22	.21	.23
Height anal	.16	.15	.14	.15	.15	.17	.15	.15	.17	.17
Length pectoral	.18	.19	.17	.15	.19	.21	.20	.19	.22	.20
Length ventral	.15	.15	.14	.14	.15	.18	.17	.15	.17	.13
Length caudal	.28	.28	.25	.25	.26	.28	.28	.26	.21	.29
Scales lateral line	56	53	54	55	51	54	50	55	53	51
Scales above lateral line	12	11	12	12	12	12	11	11	12	12
Scales below lateral line	7	6	6	7	6	7	6	6	6	6
Scales before dorsal	28	24	28	29	25	27	27	27	25	25
Dorsal rays	8	9	9	9	9	8	8	9	8	8
Anal rays	7	7	8	8	8	7	7	7	7	7

MEASUREMENTS OF SPECIMENS OF RUTILUS OREGONENSIS FROM ISOLATED BASINS OF THE OREGON LAKE SYSTEM—Continued.

From Spring, Alkali Lake.

Length of body.........mm..	88	79	95	875	87	84	83	93	89	81
Length head	.28	.30	.28	.29	.30	.27	.30	.29	.30	.30
Snout to occiput	.21	.22	.20	.225	.23	.20	.23	.22	.23	.21
Snout to dorsal	.57	.58	.57	.57	.57	.54	.59	.58	.56	.565
Snout to ventral	.58	.575	.56	.56	.57	.53	.57	.58	.56	.565
Depth body	.28	.28	.27	.29	.30	.29	.29	.26	.27	.28
Depth caudal peduncle	.13	.13	.12	.13	.13	.13	.13	.12	.12	.12
Length snout	.08	.08	.075	.08	.08	.07	.08	.08	.08	.08
Length maxillary	.08	.08	.075	.08	.08	.07	.09	.08	.075	.08
Diameter eye	.07	.07	.055	.06	.065	.06	.07	.065	.06	.07
Interorbital width	.09	.10	.09	.10	.09	.09	.095	.09	.10	.09
Height dorsal	.20	.195	.19	.19	.18	.18	.19	.18	.19	.18
Height anal	.16	.16	.15	.15	.15	.15	.14	.14	.15	.14
Length pectoral	.20	.21	.19	.19	.18	.20	.19	.17	.18	.18
Length ventral	.17	.18	.155	.16	.16	.16	.16	.15	.15	.16
Length caudal	.28	.27	.27	.27	.28	.24	.27	.26	.27	.25
Scales lateral line	51	55	52	53	52	50	48	55	55	47
Scales above lateral line	12	12	12	12	13	12	12	12	12	12
Scales below lateral line	7	6	6	7	6	7	7	6	7	6
Scales before dorsal	30	28	30	29	28	28	27	28	28	28
Dorsal rays	8	8	9	8	8	8	8	9	8	8
Anal rays	7	8	8	8	8	8	8	8	7	8

Length of body.........mm..	75	79	86	86	86	76	83	84	76	79
Length head	.29	.29	.28	.29	.29	.30	.28	.28	.30	.27
Snout to occiput	.22	.22	.21	.22	.22	.22	.22	.21	.23	.22
Snout to dorsal	.57	.555	.56	.57	.565	.575	.57	.55	.57	.56
Snout to ventral	.57	.54	.55	.57	.555	.585	.56	.55	.565	.54
Depth body	.30	.27	.27	.28	.27	.30	.27	.28	.30	.30
Depth caudal peduncle	.15	.12	.12	.13	.12	.135	.13	.13	.125	.13
Length snout	.08	.08	.07	.075	.07	.073	.075	.075	.08	.075
Length maxillary	.075	.08	.08	.08	.08	.08	.075	.075	.08	.075
Diameter eye	.07	.07	.06	.07	.065	.075	.07	.065	.075	.07
Interorbital width	.095	.095	.10	.095	.09	.10	.09	.09	.10	.09
Height dorsal	.21	.20	.18	.19	.19	.20	.20	.20	.19	.19
Height anal	.17	.16	.15	.14	.15	.17	.16	.16	.15	.16
Length pectoral	.22	.20	.19	.19	.20	.20	.20	.21	.20	.21
Length ventral	.19	.175	.15	.15	.16	.17	.16	.18	.16	.17
Length caudal	.28	.27	.25	.27	.28	.30	.28	.26	.28	.27
Scales lateral line	52	48	50	52	48	53	54	51	54	51
Scales above lateral line	12	12	13	12	12	12	12	12	12	11
Scales below lateral line	7	6	7	6	7	6	7	7	7	6
Scales before dorsal	27	28	30	28	28	28	26	27	29	27
Dorsal rays	8	8	9	8	8	8	8	8	8	8
Anal rays	7	7	10	11	8	7	8	8	8	7

From Warner Creek, Warner Lake.

Length of body.........mm..	123	125	130	129	117	112	92	110	112	111	114	116	112	140
Length head	.28	.28	.27	.275	.29	.29	.29	.285	.27	.28	.28	.27	.29	.28
Snout to occiput	.21	.205	.20	.22	.22	.22	.22	.22	.21	.22	.21	.21	.22	.215
Snout to dorsal	.555	.56	.57	.58	.585	.56	.58	.56	.56	.56	.57	.56	.56	.57
Snout to ventral	.55	.56	.57	.58	.585	.565	.58	.575	.55	.565	.57	.57	.57	.57
Depth body	.265	.26	.285	.275	.26	.275	.28	.255	.26	.27	.28	.26	.28	.27
Depth caudal peduncle	.13	.13	.13	.12	.13	.13	.14	.12	.125	.12	.14	.13	.13	.13
Length snout	.085	.08	.08	.08	.085	.085	.085	.09	.08	.08	.08	.08	.085	.08
Length maxillary	.085	.085	.08	.08	.085	.085	.085	.08	.08	.085	.08	.08	.085	.085
Diameter eye	.055	.06	.05	.05	.055	.06	.06	.05	.055	.06	.06	.055	.06	.05
Interorbital width	.095	.095	.09	.09	.10	.095	.095	.095	.095	.095	.09	.10	.10	.09
Height dorsal	.18	.18	.18	.19	.19	.21	.22	.205	.195	.195	.23	.20	.195	.18
Height anal	.16	.155	.15	.15	.155	.17	.18	.165	.16	.165	.195	.16	.16	.16
Length pectoral	.185	.18	.17	.18	.18	.19	.20	.19	.17	.18	.24	.17	.185	.17
Length ventral	.15	.15	.16	.155	.155	.17	.18	.18	.15	.15	.19	.155	.16	.155
Length caudal	.25	.25	.24	.25	.25	.29	.28	.28	.265	.26	.30	.255	.28	.26
Scales lateral line	53	52	55	55	55	54	52	53	51	51	51	52	51	51
Scales above lateral line	12	12	13	13	12	12	12	12	12	12	12	12	12	12
Scales below lateral line	7	6	8	7	7	7	7	7	6	6	7	7	7	6
Scales before dorsal	28	30	30	29	30	30	31	31	28	30	29	27	30	33
Dorsal rays	9	9	8	8	9	8	9	8	9	9	9	9	8	8
Anal rays	8	8	8	8	8	8	7	8	8	8	8	8	8	7

MEASUREMENTS OF SPECIMENS OF RUTILUS OREGONENSIS FROM ISOLATED BASINS OF THE OREGON LAKE SYSTEM—Continued.

From Warner Creek, Warner Lake—Continued.

Length of body.........mm..	64	91	75	75	87	75	81	81	84	85	89	80	89	92
Length head	.30	.27	.29	.30	.275	.28	.28	.29	.27	.28	.28	.285	.28	.29
Snout to occiput	.23	.21	.22	.235	.21	.21	.22	.22	.22	.225	.225	.225	.215	.22
Snout to dorsal	.56	.55	.57	.57	.55	.58	.60	.58	.56	.57	.59	.57	.57	.575
Snout to ventral	.56	.55	.57	.56	.55	.575	.575	.57	.565	.555	.58	.56	.57	.565
Depth body	.27	.27	.30	.28	.27	.275	.265	.27	.28	.27	.29	.285	.255	.27
Depth caudal peduncle	.13	.13	.13	.13	.12	.135	.12	.13	.13	.12	.13	.12	.12	.13
Length snout	.085	.08	.08	.09	.075	.08	.08	.09	.075	.08	.085	.09	.08	.085
Length maxillary	.085	.08	.08	.08	.075	.085	.08	.09	.08	.08	.09	.08	.08	.08
Diameter eye	.07	.06	.07	.07	.06	.06	.06	.07	.06	.06	.06	.07	.06	.06
Interorbital width	.10	.09	.10	.09	.085	.095	.08	.095	.085	.09	.095	.095	.095	.095
Height dorsal	.22	.22	.22	.20	.19	.19	.185	.19	.22	.19	.20	.20	.19	.20
Height anal	.18	.17	.17	.155	.145	.14	.15	.15	.18	.145	.155	.15	.15	.15
Length pectoral	.21	.21	.20	.20	.16	.17	.165	.16	.22	.19	.18	.18	.17	.175
Length ventral	.175	.18	.17	.165	.145	.16	.145	.14	.19	.15	.155	.155	.15	.165
Length caudal	.29	.29	.28	.25	.25	.26	.255	.25	.27	.25	.27	.28	.25	.26
Scales lateral line	50	52	53	56	54	49	56	55	51	49	49	52	52	52
Scales above lateral line	12	12	11	13	13	12	12	13	13	13	12	12	12	13
Scales below lateral line	6	6	7	8	7	7	7	7	8	7	7	7	7	7
Scales before dorsal	27	30	29	30	27	30	28	27	29	29	27	30	29	29
Dorsal rays	8	8	8	8	9	9	9	9	8	8	9	8	8	8
Anal rays	8	9	8	8	8	8	8	8	8	8	8	8	8	8

Rutilus columbianus, new species.

Closely related to *R. oregonensis*, *R. thalassinus*, and *R. bicolor*, from each of which it differs as follows: From *R. oregonensis* in having larger scales; from *R. thalassinus* in its shorter fins, fewer scales in the lateral series, and a larger number between occiput and dorsal fin; from *R. bicolor* in having a larger

FIG. 4.—Rutilus columbianus, new species. Type.

head, higher anal, longer caudal, fewer scales in the lateral line, a larger number between occiput and dorsal fin, and in usually having one more ray in the dorsal fin. The tabulation on page 94 will show some of the distinctive characters of these forms in greater detail.

Description of type no. 55595, U. S. National Museum, from Warm Springs, near Harney Lake, Harney County, Oreg.: Total length, 136 mm. Head, 3.7 in length to base of caudal; depth, 3.6; depth caudal peduncle, 8.4; depth head at occiput, 4.7; length snout, 3.5 in head; maxillary, 3.5; diameter eye, 5.6; width space between eyes, 3.1; height dorsal, 1.6; anal, 2.1; length pectoral, 1.7; ventral, 1.9; caudal, 1.2; scales, 12–49–7; between occiput and origin of dorsal, 27.

Dorsal contour with an abrupt elevation at occiput, which is less prominent in young individuals; mouth very oblique, maxillary extending to a vertical passing midway between nostril and eye; lower

jaw projecting slightly; gillrakers 16, sometimes 14 or 15, very short and pointed; teeth 4–5, rather stout, the posterior one more slender than others; grinding surface well developed; tips of teeth, especially the middle ones, slightly hooked; peritoneum dusky; intestinal canal short, about 1⅓ times total length of fish; lateral line complete, decurved just behind head; origin of dorsal immediately above that of ventral, free edge of fin behind third ray slightly concave; free edge of anal straight; pectorals and ventrals short and rounded, the latter not reaching anal opening, in some examples extending to base of anal fin; lobes of caudal rather acutely pointed.

Color in alcohol silvery, very dark on upper parts. In life, specimens taken at Warm Springs were of a remarkably beautiful deep-green color on the dorsal parts, the sides being tinged with brassy. The cheeks and opercles were steel blue, growing brassy toward the ventral parts. The pectorals, ventrals, and anal were tinged with red. Examples from Silvies River were not so highly colored.

The fins of males are sometimes slightly longer than those of females. The appended table will show some individual variations.

Specimens were taken in the Malheur basin from Silvies River near Burns, and from Warm Springs.

The presence of this species in the Columbia River was discovered by Dr. C. H. Gilbert, who found specimens in the Portland market, and also collected them in the Weiser River at Weiser, Idaho, and in the Payette River at Payette, Idaho. Its relation to the form found in the Bonneville basin is not known.

MEASUREMENTS OF SPECIMENS OF RUTILUS COLUMBIANUS.

From Warm Springs, Harney County, Oreg.

Length of body ... mm..	126	144	119	112	109	109	107	105	103	101
Length head	.29	.28	.28	.28	.29	.29	.29	.30	.28	.30
Snout to occiput	.23	.22	.215	.22	.22	.22	.225	.22	.22	.22
Snout to dorsal	.585	58	.56	.56	.60	.58	.59	.58	.56	.57
Snout to ventral	.57	.57	.55	.56	.58	.57	.58	.575	.56	.55
Depth body	.27	.28	.29	.29	.28	.27	.30	.30	.28	.29
Depth caudal peduncle	.13	.125	.13	.13	.13	.12	.125	.13	.13	.13
Length snout	.09	.09	.08	.08	.09	.08	.09	.085	.09	.085
Length maxillary	.09	.09	.075	.075	.09	.09	.09	.085	.085	.085
Diameter eye	.055	.05	.055	.06	.055	.06	.05	.055	.06	.06
Interorbital width	.10	.10	.085	.08	.09	.09	.10	.11	.09	.10
Height dorsal	.18	.19	.21	.20	.20	.20	.19	.19	.18	.23
Height anal	.15	.15	.18	.17	.15	.16	.15	.15	.15	.18
Length pectoral	.17	.18	.20	.20	.17	.18	.17	.18	.16	.21
Length ventral	.16	.155	.19	.19	.16	.16	.16	.16	.14	.20
Length caudal	.28	.265	.29	.28	.26	.27	.28	.25	.25	.30
Scales lateral line	49	45	45	46	45	46	47	45	45	43
Scales above lateral line	12	11	11	11	12	11	11	12	11	11
Scales below lateral line	6	6	6	5	6	5	6	5	6	6
Scales before dorsal	27	28	29	26	26	27	27	28	25	27
Dorsal rays	8	9	9	9	9	8	9	9	9	9
Anal rays	8	8	8	9	8	8	8	8	8	8

Length of body ... mm..	95	98	97	95	90	91	85	83	77
Length head	.30	.29	.29	.29	.29	.28	.29	.31	[illegible]
Snout to occiput	.225	.22	.22	.22	.23	.22	.23	.24	[illegible]
Snout to dorsal	.60	.58	.575	.57	.59	.57	.60	.58	.59
Snout to ventral	.59	.57	.57	.57	.57	.575	.59	.57	.58
Depth body	.27	.27	.28	.31	.27	.29	.29	.30	.27
Depth caudal peduncle	.125	.12	.13	.13	.13	.12	.12	.12	.12
Length snout	.095	.085	.085	.09	.09	.08	.09	.09	.09
Length maxillary	.095	.08	.085	.085	.09	.08	.085	.095	.09
Diameter eye	.06	.05	.06	.065	.06	.055	.065	.055	.07
Interorbital width	.10	.09	.10	.09	.10	.09	.10	.10	.10
Height dorsal	.20	.20	.215	.22	.19	.18	.21	.20	.21
Height anal	.18	.17	.18	.185	.15	.14	.16	.16	.15
Length pectoral	.18	.19	.21	.22	.16	.15	.18	.17	.17
Length ventral	.17	.17	.19	.19	.15	.14	.16	.16	.16
Length caudal	.27	.30	.28	.28	.27	.27	.28	.27	.27
Scales lateral line	45	45	43	45	44	48	45	44	45
Scales above lateral line	12	11	11	12	11	12	11	11	11
Scales below lateral line	6	6	7	6	6	7	6	5	5
Scales before dorsal	26	26	27	28	26	27	26	25	24
Dorsal rays	9	8	9	9	8	9	8	9	9
Anal rays	8	8	8	8	8	8	8	8	8

MEASUREMENTS OF SPECIMENS OF RUTILUS COLUMBIANUS—Continued.

From market, Portland, Oreg.

Length of body......mm..	167	176	185	157	Height anal................	.155	.17	.165	.18
Length head..............	27	.275	.26	.27	Length pectoral..........	.15	.18	.17	.18
Snout to occiput..........	.20	.19	.19	.20	Length ventral............	.16	.16	.16	.185
Snout to dorsal............	.56	.56	.55	.565	Length caudal.....	.24	.29	....	.295
Snout to ventral..........	.55	.56	.55	.565	Scales lateral line..........	50	49	46	46
Depth caudal peduncle....	.125	.13	.13	.135	Scales above lateral line.	12	12	12	12
Length snout..............	.07	.07	.07	.07	Scales below lateral line....	7	7	6	7
Diameter eye..............	.055	.05	.045	.05	Scales before dorsal....	28	28	29	30
Interorbital width.........	.09	.09	.095	.09	Dorsal rays................	9	9	9	9
Height dorsal..............	.19	.20	.20	.215	Anal rays..................	8	9	9	8

Rutilus bicolor (Girard).

A table of measurements of specimens of this species is introduced for comparison with other forms.

MEASUREMENTS OF SPECIMENS OF RUTILUS BICOLOR FROM SHASTA RIVER, NEAR YREKA, CAL.

Length of body..................... mm..	124	121	119	117	114	105	107	103	101	105
Length head..............................	.265	.26	.25	.27	.27	.27	.28	.265	.27	.27
Snout to occiput..........................	.20	.20	.20	.205	.21	.21	.20	.20	.21	.20
Snout to dorsal............................	.555	.52	.52	.55	.57	.56	.555	.555	.56	.50
Snout to ventral..........................	.53	.54	.52	.54	.55	.55	.555	.535	.55	.56
Depth body................................	.28	.29	.28	.27	.28	.28	.29	.28	.27	.28
Depth caudal peduncle.....................	.125	.125	.125	.12	.12	.12	.125	.12	.12	.125
Length snout..............................	.075	.08	.075	.085	.085	.085	.08	.08	.08	.08
Length maxillary..........................	.08	.08	.075	.075	.087	.075	.08	.075	.075	.08
Diameter eye..............................	.055	.055	.05	.055	.055	.055	.055	.06	.055	.06
Interorbital width.........................	.095	.085	.09	.09	.10	.09	.09	.09	.09	.09
Height dorsal..............................	.175	.18	.18	.18	.20	.19	.19	.195	.20	.20
Height anal................................	.14	.14	.13	.14	.15	.14	.15	.13	.14	.15
Length pectoral............................	.17	.16	.17	.15	.175	.18	.17	.17	.16	.20
Length ventral.............................	.14	.14	.15	.155	.14	.16	.15	.15	.15	.18
Length caudal..............................	.25	.24	.23	.22	.27	.24	.25	.22	.24	.25
Scales lateral line.........................	44	49	48	46	45	47	48	48	45	46
Scales above lateral line..................	11	11	10	10	10	11	11	10	11	11
Scales below lateral line..................	6	7	6	6	7	6	7	6	5	7
Scales before dorsal......................	22	27	25	25	25	25	25	25	24	24
Dorsal rays................................	8	9	9	8	8	8	8	8	8	8
Anal rays..................................	8	8	7	8	7	8	8	8	8	7
Length of body.....................mm..	105	89	97	90	90	76	78	90	85	81
Length head..............................	.25	.275	.27	.27	.27	.27	.28	.27	.26	.285
Snout to occiput..........................	.20	.205	.205	.21	.20	.20	.21	.21	.21	.21
Snout to dorsal............................	.545	.55	.55	.55	.56	.56	.57	.56	.55	.57
Snout to ventral..........................	.545	.55	.55	.54	.56	.56	.56	.56	.54	.57
Depth body................................	.29	.31	.30	.29	.30	.25	.28	.30	.26	.28
Depth caudal peduncle.....................	.12	.12	.12	.125	.12	.12	.13	.12	.12	.13
Length snout..............................	.075	.085	.08	.08	.08	.08	.085	.08	.08	.085
Length maxillary..........................	.075	.08	.075	.08	.075	.075	.08	.08	.075	.075
Diameter eye..............................	.055	.06	.06	.06	.06	.06	.065	.06	.06	.065
Interorbital width.........................	.08	.10	.09	.09	.09	.09	.10	.095	.085	.095
Height dorsal..............................	.18	.20	.19	.19	.20	.19	.20	.20	.185	.20
Height anal................................	.13	.15	.15	.15	.16	.14	.15	.15	.135	.15
Length pectoral............................	.16	.17	.16	.20	.18	.16	.17	.165	.16	.16
Length ventral.............................	.14	.16	.15	.17	.16	.15	.15	.15	.14	.15
Length caudal..............................	.24	.255	.25	.27	.28	.25	....	.24	.25	.26
Scales lateral line.........................	51	46	46	45	45	47	44	49	46	46
Scales above lateral line..................	11	11	11	10	10	11	12	10	10	10
Scales below lateral line..................	6	6	6	6	7	7	6	5	6	7
Scales before dorsal......................	26	25	21	23	25	25	25	23	26	25
Dorsal rays................................	9	8	8	9	8	8	9	8	8	9
Anal rays..................................	8	7	8	8	7	8	8	8	8	8

COMPARISON OF CERTAIN DISTINCTIVE CHARACTERS OF RUTILUS THALASSINUS, R. OREGONENSIS, R. COLUMBIANUS, AND R. BICOLOR.

Length head.

Species.	0.23.	0.25.	0.26.	0.27.	0.28.	0.29.	0.30.	0.31.
R. thalassinus..............................	1	....	2	10	15	18	10	3
R. oregonensis..............................	....	1	13	36	66	57	16	5
R. columbianus..............................	....	....	....	3	11	22	6	2
R. bicolor..................................	....	2	2	12	3	1	....	....

COMPARISON OF CERTAIN DISTINCTIVE CHARACTERS OF RUTILUS THALASSINUS, R. OREGONENSIS, R. COLUMBIANUS, AND R. BICOLOR—Continued.

Snout to occiput.

Species.	0.18.	0.19.	0.20.	0.21.	0.22.	0.23.	0.24.	0.25.	0.27.	0.29.
R. thalassinus			2	10	21	17	7	1		1
R. oregonensis	1	1	20	57	85	26	3		1	
R. columbianus			1	5	19	16	2	1		
R. bicolor			9	11						

Snout to dorsal.

Species.	0.52.	0.53.	0.54.	0.55.	0.56.	0.57.	0.58.	0.59.	0.60.
R. thalassinus			1	2	11	15	18	11	1
R. oregonensis		2	12	28	55	47	42	7	1
R. columbianus			1		8	9	15	6	5
R. bicolor	2			6	9	3			

Height dorsal.

Species.	0.15.	0.17.	0.18.	0.19.	0.20.	0.21.	0.22.	0.23.	0.24.	0.25.	0.26.
R. thalassinus			2	1	5	16	10	13	7	2	2
R. oregonensis	1	11	31	55	64	18	10	3			
R. columbianus			3	6	15	14	5	1			
R. bicolor			5	6	9						

Height anal.

Species.	0.13.	0.14.	0.15.	0.16.	0.17.	0.18.	0.19.	0.20.
R. thalassinus			1	15	6	18	12	4
R. oregonensis	6	33	72	51	20	6		
R. columbianus		1	12	13	11	6	1	
R. bicolor	3	7	9	1				

Length ventral.

Species.	0.13.	0.14.	0.15.	0.16.	0.17.	0.18.	0.19.	0.20.
R. thalassinus			3	13	8	21	10	4
R. oregonensis	6	15	53	67	31	16	5	
R. columbianus		2	3	17	9	6	6	1
R. bicolor		5	9	4	1	1		

Length caudal.

Species.	0.21.	0.22.	0.23.	0.24.	0.25.	0.26.	0.27.	0.28.	0.29.	0.30.	0.31.	0.32.	0.33.	0.34.
R. thalassinus					1	1		7	9	12	8	11	6	4
R. oregonensis	1	1	7	25	47	40	21	24	7	2				
R. columbianus					2	3	12	19	4	3				
R. bicolor		2	1	5	6	2	2	1						

COMPARISON OF CERTAIN DISTINCTIVE CHARACTERS OF RUTILUS THALASSINUS, R. OREGONENSIS, R. COLUMBIANUS, AND R. BICOLOR—Continued.

Scales lateral line.

Species.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.
R. thalassinus:											
Pit River							6	8	5	6	7
Goose Lake						2	1	1	1	2	5
Muddy Creek					2	4	5	9	7	9	7
Total					2	6	12	18	13	17	19
R. oregonensis:											
Chewaucan River								1	1	1	1
XL Spring									1	3	2
Ana River										1	3
Silver Lake								2	4	8	8
Alkali Spring						1	3	6	11	11	12
Warner Lake						1	2	5	4	10	10
Total						2	5	14	21	34	36
R. columbianus:											
Warm Spring	1	1	7	9	7	19	11	5	4	1	1
Silvies River			1	2	3	3	4	5	5	4	3
Total	1	1	8	11	10	22	15	10	9	5	4
R. bicolor:											
Klamath Lake						3	1	2	2	3	2
Shasta River				1	6	8	10	8	11	13	6
Total				1	6	11	11	10	13	16	8

Species.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
T. thalassinus:										
Pit River	12	7	2	2						
Goose Lake	1									
Muddy Creek	3	2	2							
Total	16	9	4	2						
R. oregonensis:										
Chewaucan River	2	4	2	5	5	2	2			1
XL Spring	5	4	7	11	14	6	5	1	2	
Ana River	2	6	8	8	9	9	8	4	1	
Silver Lake	8	7	7	8	9	2	2	3	2	
Alkali Spring	18	14	10	11	6	3	2		1	
Warner Lake	11	21	10	8	14	4	2	1		
Total	46	56	44	51	57	26	21	9	6	1
R. columbianus:										
Warm Spring										
Silvies River	1									
Total	1									
R. bicolor:										
Klamath Lake	1									
Shasta River	6	2	1	1						
Total	7	2	1	1						

Scales before dorsal.

Species.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.
R. thalassinus		1	8	10	16	13	9	2					
R. oregonensis				3	18	9	27	23	34	36	20	10	4
R. columbianus				3	8	9	12	5	2				
R. bicolor	1	1	2	2	11	2	1						

COMPARISON OF CERTAIN DISTINCTIVE CHARACTERS OF RUTILUS THALASSINUS, R. OREGONENSIS, R. COLUMBIANUS, AND R. BICOLOR—Continued.

Scales above lateral line.

Species.	10.	11.	12.	13.	14.	Species.	10.	11.	12.	13.	14.
R. thalassinus	5	47	6	1		R. columbianus		17	21	1	
R. oregonensis		24	109	54	6	R. bicolor	9	10	1		

Dorsal rays.

Species.	7.	8.	9.	Species.	7.	8.	9.
R. thalassinus			59	R. columbianus		9	35
R. oregonensis	1	130	61	R. bicolor		14	6

Anal rays.

Species.	7.	8.	9.	10.	11.	Species.	7.	8.	9.	10.	11.
R. thalassinus	1	46	12			R. columbianus		43	1		
R. oregonensis	54	135	3	1	1	R. bicolor	5	15			

Rutilus symmetricus (Baird & Girard).

Drew Creek, Muddy Creek, and Cottonwood Creek, in Lake County, Oreg.

This species is to be distinguished from *R. thalassinus* by its shorter head, more slender body, and more nearly horizontal lower jaw. The dorsal fin is inserted posterior to the ventral, while in *R. thalassinus* it is almost immediately above it. Individuals of the species are not known to grow so large as those of *R. thalassinus*, and while specimens of the two species may occasionally be taken together, the latter generally prefers deeper and more quiet water.

An examination of specimens from Drew Creek along with others from Putah Creek, in a distant part of the Sacramento Basin, shows that the former usually have fewer dorsal and anal rays and shorter fins. The peculiar character of the Drew Creek examples is further maintained by a comparison with individuals from Napa River and from the streams tributary to San Francisco Bay. Careful measurements[a] of many specimens from the latter basin demonstrate that the fins of the males are generally much longer than those of the females, the difference being especially pronounced in the pectorals. The same sexual difference is also to be found in representatives from Drew Creek and other streams.

TABLE SHOWING COMPARATIVE LENGTH OF FINS AND NUMBER OF DORSAL AND ANAL RAYS IN SPECIMENS OF RUTILUS SYMMETRICUS FROM DIFFERENT LOCALITIES.

	Drew Creek.	Putah Creek.	Napa River.
Height anal:			
0.14	6		
.15	6		1
.16	6	2	3
.17	2	3	9
.18		5	13
.19		4	11
.20			3
.21		1	
Length pectoral:			
0.16	8		
.17	6		3
.18	3	5	7
.19	2	4	10
.20[b]	1	1	6
.21[b]		1	
.22		1	2
0.23		2	10
.24		1	5
Length ventral:			
0.12	3		
.13	10		3
.14	3		7
.15	4	9	12
.16		3	7
.17		3	12
Dorsal rays:			
8	20	25	
9		31	68
Anal rays:			
7	20	1	
8		52	67
9		3	1

[a] Snyder, J. O., Report Bureau of Fisheries 1904, p. 332.

[b] The 0.20–0.21 line divides females and males.

MEASUREMENTS OF SPECIMENS OF RUTILUS SYMMETRICUS FROM DREW CREEK, LAKE COUNTY, OREG.

		♀	♀	♀	♀	♂	♀	♀	♀	♂
Length of body.......mm..	72	69	44	71	61	65	62	64	62	58
Length head	.255	.26	.27	.255	.26	.245	.255	.26	.26	.26
Depth caudal peduncle	.10	.11	.11	.11	.11	.11	.11	.105	.11	.12
Length caudal peduncle	.23	.235	.22	.227	.225	.24	.23	.23	.22	.23
Length snout	.08	.08	.08	.08	.085	.07	.085	.085	.085	.09
Interorbital width	.085	.095	.10	.095	.085	.085	.09	.085	.09	.085
Snout to dorsal	.56	.55	.57	.56	.56	.53	.57	.55	.58	.575
Snout to ventral	.525	.515	.54	.535	.52	.515	.54	.525	.525	.53
Height dorsal	.17	.17	.18	.18	.175	.195	.175	.175	.17	.18
Height anal	.14	.135	.15	.15	.14	.16	.14	.15	.14	.155
Length pectoral	.17	.16	.18	.16	.17	.185	.165	.16	.155	.17
Length ventral	.13	.12	.12	.125	.125	.15	.125	.13	.125	.13
Length caudal	.25	.24	.27	.265	.255	.25	.25	.26	.24	.26
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	57	59	56	57	55	61	57	58	54	56
Scales above lateral line	13	13	13	12	14	12	13	13	13	12
Scales before dorsal	38	36	38	38	34	34	37	34	38	37
	♂	♀	♀	♀	♀	♀	♀	♂	♂	♂
Length of body.......mm..	61	58	59	55	60	55	54	52	52	52
Length head	.265	.26	.265	.265	.27	.265	.265	.26	.265	.26
Depth caudal peduncle	.12	.11	.11	.11	.105	.11	.105	.12	.11	.105
Length caudal peduncle	.23	.22	.24	.225	.24	.25	.24	.24	.23	.24
Length snout	.09	.09	.085	.08	.095	.08	.08	.075	.08	.0[illegible]5
Interorbital width	.09	.0[illegible]5	.09	.10	.0[illegible]5	.085	.09	.09	.095	.095
Snout to dorsal	.58	.57	.55	.575	.575	.57	.57	.55	.56	.565
Snout to ventral	.525	.545	.52	.53	.53	.54	.525	.525	.54	.525
Height dorsal	.19	.175	.185	.18	.18	.20	.18	.20	.19	.185
Height anal	.16	.14	.145	.15	.16	.17	.145	.165	.16	.155
Length pectoral	.18	.155	.175	.16	.16	.17	.16	.19	.20	.165
Length ventral	.15	.12	.13	.13	.125	.135	.135	.15	.145	.135
Length caudal	.275	.26	.27	.27	.26	.265	.25	.265	.27	.27
Dorsal rays	8	8	8	8	8	7	8	8	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	59	60	59	55	60	56	60	61	57	58
Scales above lateral line	13	15	14	13	13	14	13	14	13	14
Scales before dorsal	35	38	33	35	33	34	33	32	35	31

Agosia nubila carringtoni (Cope).

The examples of *Agosia* taken in the Malheur, Oregon Lake, and Upper Sacramento basins are all provisionally included under the above name. In the recognition of this form, and also of *A. klamathensis*, the size of the scales seems to be the only distinctive character that has been observed.[a] The specimens from the Malheur basin have 60 to 79 scales in the lateral line, thus agreeing with examples of *A. nubila carringtoni* from the upper Snake River. Those from the Oregon Lake system have 66 to 81 scales, resembling the Klamath form, *A. klamathensis*, and differing from a recently described Lahontan species which has 56 to 77 scales.[b] Examples from Goose Lake and its tributaries have 61 to 74 scales in the lateral series and are apparently indistinguishable from those of the upper Snake River and Malheur basins; but the matter is not simplified when specimens from other parts of the Sacramento basin are found to have as few as 50 scales, thus resembling *A. nubila nubila* of the Columbia River.

The *Agosia* from the Klamath basin is said to have the barbel constantly present. In specimens from the Oregon Lake basin it is usually present, although it may be absent in many cases. It will be noted in the following table that specimens from Silver Creek (Malheur basin) have barbels, while those from Warm Springs have none.

Specimens were taken in the following localities: Cottonwood Creek, Drew Creek, Muddy Creek, and Goose Lake, Oregon; Joseph Creek, Burney Creek, and Rush Creek, California; Warner Creek, Honey Creek, Chewaucan River near Paisley and at mouth, Silver Creek, in Lake County, Bridge Creek, Buck Creek, Silver Creek, in Harney County, and Warm Springs.

[a] Gilbert, C. H., & Evermann, B. W., Bulletin U. S. Fish Commission, vol. XIV, 1894, p. 191-193. Evermann, B. W., & Meek, S. E., ibid., vol. XVII, 1897, p. 74. Gilbert, C. H., ibid., vol. XVII, 1897, p. 9.

[b] Rutter, Cloudsley, Bulletin U. S. Fish Commission, vol. XXII, 1902, p. 148, *Agosia robusta*.

TABLE SHOWING PRESENCE OF BARBEL IN AGOSIA NUBILA CARRINGTONI.

Locality.	Barbel present on both sides.	Present only on one side.	Absent.	Locality.	Barbel present on both sides.	Present only on one side.	Absent.
Malheur basin:				Oregon Lake system—Continued.			
Silver Creek, Harney County...	50	2	1	Bridge Creek....................	12	5	7
Warm Springs..................	....	....	21	Silver Creek, (Silver Lake).....	22	6	39
Oregon Lake system:				Goose Lake basin:			
Honey Creek....................	25	2	4	Cottonwood Creek...............	2	1	12
Warner Creek..................	18	....	4	Burney Creek....................	7	5	40
Chewaucan River...............	39	4	5				

SCALES IN LATERAL LINE OF AGOSIA NUBILA CARRINGTONI AS SHOWN BY 417 SPECIMENS.

Scales.	Silver Creek.	Warm Springs.	Warner Creek.	Honey Creek.	Chewaucan River.	Silver Creek.	Bridge Creek.	Cottonwood Creek.	Drew Creek.	Muddy Creek.	Joseph Creek.	Burney Creek.
	Specimens.	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
50												2
51												3
52												4
53												4
54												3
55											2	11
56												12
57											1	13
58												10
59											2	12
60	1										1	8
61	3										3	8
62	3	1						1			2	5
63	5	2						1			1	3
64	6	1							1	2	1	4
65	6	2						1		1	2	2
66	5	2				2		2	1			1
67	4	2				3	2	8	1	1		1
68	10	1	1		1	4	2	2	1	1	1	
69	9	2	1	1	2	5	2	3	2			
70	7	2	2	1		4	2	5				
71	7	2	1	2	2	5	1	2	1			
72	9	3	2	4	2	5	3	2		2		
73	4		2	3	1	8	4	1	1			
74	4		2	5	4	7	3	1				
75	[illegible]	1		[illegible]	3	1	1					
76	3		2	2	2	1						
77	3		3	1		1	1					
78	2		1		1							
79	1		2									
80			2			1						
81			1									

MEASUREMENTS OF SPECIMENS OF AGOSIA NUBILA CARRINGTONI FROM VARIOUS LOCALITIES.

Silver Creek, Harney County, Oreg.

Length of body ... mm	66	62	59	59	60	62	64	53	52	65
Length head	.24	.24	.24	.25	.25	.25	.25	.25	.26	.25
Depth caudal peduncle	.115	.11	.115	.11	.12	.11	.11	.115	.12	.11
Length caudal peduncle	.24	.25	.265	.24	.265	.25	.27	.26	.26	.25
Length snout	.085	.09	.08	.085	.09	[illegible]	.09	[illegible]	[illegible]	[illegible]
Diameter eye	.055	.05	.055	.05	.05	.05	.055	.05	.05	.05
Snout to dorsal	.58	.56	.56	.58	.56	.59	.55	.54	.55	.58
Snout to ventral	.53	.51	.495	.51	.50	.52	.50	.49	.49	.51
Height dorsal	.185	.17	.19	.175	.185	.17	.185	.20	.18	.18
Height anal	.185	.17	.18	.175	.19	.17	.18	.20	.185	.17
Length pectoral	.20	.18	.18	.175	.20	.19	.18	.22	.22	.18
Length ventral	.16	.14	.15	.15	.16	.15	.15	.17	.15	.14
Length caudal	.23	.22	.24	.22	.23	.23	.23	.22	.22	.22
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7

MEASUREMENTS OF SPECIMENS OF AGOSIA NUBILA CARRINGTONI FROM VARIOUS LOCALITIES—Con.

From Chewaucan River, Lake County, Oreg.

Length of body ....mm..	74	64	60	59	57	53	54	55	51	46
Length head	.25	.25	.24	.26	.26	.25	.25	.27	.27	.26
Depth body	.21	.215	.22	.24	.25	.19	.21	.21	.225	.20
Depth caudal peduncle	.11	.12	.115	.125	.12	.12	.12	.12	.12	.12
Length caudal peduncle	.245	.25	.24	.24	.24	.26	.26	.24	.25	.27
Length snout	.10	.09	.08	.09	.09	.08	.08	.09	.10	.09
Diameter eye	.045	.05	.05	.05	.05	.055	.05	.055	.06	.06
Snout to dorsal	.57	.555	55	.57	.58	.56	.57	.58	.56	57
Snout to ventral	.52	.495	.53	.52	.52	.50	.50	.51	.52	.51
Height dorsal	.17	.175	.17	.17	.18	.18	.19	.19	.18	.19
Height anal	.17	.165	.16	.17	.18	.18	.17	.18	.18	.175
Length pectoral	.18	.18	.18	.17	.19	.21	.22	.20	.19	.19
Length ventral	.13	.13	.125	.13	.15	.13	.13	.14	.14	.13
Length caudal	.22	.22	.21	.25	.255	.25	.24	.25	.25	.24
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	8	7	7	7	7	7	7	7	7	7

From Honey Creek, Warner Lake, Oreg.

Length of body ....mm..	58	55	54	54	51	50	50	47	45	43
Length head	.25	.255	.26	.26	.25	.26	.26	.26	.28	.27
Depth body	.25	.24	.24	.22	.25	.23	.22	.24	.24	.22
Depth caudal peduncle	.125	.135	.13	.13	.14	.14	.13	.14	.13	.14
Length caudal peduncle	.26	.25	.24	.25	.26	.24	.26	.25	.25	.25
Length snout	.085	.09	.09	.09	.08	.09	.085	.09	.09	.09
Diameter eye	.05	.05	.06	.05	.05	.045	.06	.055	.06	.06
Snout to dorsal	.58	.59	.58	.57	.57	.57	.55	.55	.58	.56
Snout to ventral	.52	.54	.54	.53	.51	.54	.53	.53	,54	.52
Height dorsal	.17	.16	.16	.18	.17	.18	.17	.18	.18	.19
Height anal	.16	.15	.16	.16	.16	.17	.17	.16	.17	.18
Length pectoral	.165	.165	.16	.18	.20	.17	.17	.21	.19	.22
Length ventral	.12	.12	.13	.13	.13	.13	.12	.13	.13	.15
Length caudal	.25	.23	.24	.24	.25	.25	.25	.25	.24	.26
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7

From Burney Creek, Shasta County, Cal.

Length of body ....mm..	63	62	59	58	62	53	51	58	59	55
Length head	.25	.25	.25	.25	.25	.25	.25	.24	.24	.25
Depth body	.26	.24	.25	.26	.25	.25	.26	.24	.23	.23
Depth caudal peduncle	.115	.11	.115	.12	.11	.12	.12	.12	.11	.12
Length caudal peduncle	.23	.23	.23	.225	.23	.24	.23	.25	.23	.23
Length snout	.09	.08	.08	.085	.09	.085	.085	.08	.08	.085
Diameter eye	.05	.05	.055	.05	.055	.05	.05	.05	.05	.05
Snout to dorsal	.58	.56	.57	.59	.59	.58	.59	.57	.57	.59
Snout to ventral	.52	.53	.53	.53	.53	.52	.54	.51	.51	.53
Height dorsal	.16	.16	.16	.17	.18	.16	.175	.18	.18	.17
Height anal	.16	.16	.17	.16	.17	.15	.175	.17	.16	.16
Length pectoral	.16	.16	.16	.16	.17	.18	.16	.16	.16	.17
Length ventral	.13	.13	.13	.13	.14	.13	.14	.13	.14	.12
Length caudal	.23	.22	.22	.22	.20	.23	.24	.24	.22	.22
Dorsal rays	8	8	8	8	8	7	8	8	8	7
Anal rays	7	7	7	7	7	7	7	7	7	7

Salmo clarkii Richardson.

Goose Lake; Pitt River, Alturas; Burney Creek; Cottonwood Creek; Drew Creek; Warner Creek; Honey Creek; Chewaucan River; Paisley; Chewaucan River near mouth; Silver Creek, Buck Creek, Bridge Creek, Silver Creek, Harney County; Silvies River.

The trout of the region under study are generally brightly colored and profusely spotted. Round, sharply outlined spots are present on the head and along the upper parts of the body, growing less regular in outline posteriorly. Along the sides are 2 or 3 rows of large, oval spots underlying the smaller, darker ones. A row along the lateral line is always present except in very large individuals, where sometimes none but the smaller spots persist. The more brightly marked individuals generally have a red dash on the mandible. In the same stream, however, specimens may be found having the red of the mandible scarcely discernible or entirely absent. The dorsal fin has 4 or 5 rows of black spots, the caudal is always spotted, while the other fins and the ventral surface are immaculate.

There are some pronounced variations of a local nature. Examples from the region of Silver Lake have the small black spots usually absent on the head and sparsely scattered along the back, becoming somewhat larger and more plentiful posteriorly, but not extending on the sides. The oval spots along the lateral line are very large, extending upward well toward the back. Specimens from Cottonwood Creek have few spots on the head and anterior parts of body, but are otherwise colored after the usual pattern. The number of scales in the lateral series is as follows: Chewaucan River, 147 to 151; Honey Creek, 154 to 178; Buck Creek, 146 to 160; Cottonwood Creek, 153 to 168; Silver Creek, 156 to 174; the data based on 10 specimens from each locality.

There is some question as to whether the trout of the region is indigenous, testimony on the point being frequently conflicting. For example, the writer was informed by certain old residents of the Warner Lake region that no native trout was found there, the streams having been artificially stocked, while other residents felt just as certain that although fishes were introduced from other localities, native trout had always been plentiful.

Cottus gulosus (Girard).

Drew Creek, Lake County, Oreg. (1 example, dorsal VIII, 19, anal 14); Pitt River, near Canby (1 example, dorsal VII, 19, anal 13). Both have a prickly area beneath pectoral, about as long as the snout; dorsals joined, the membrane extending upward on first ray a distance equal to diameter of pupil; teeth on vomer, none on palatines.

Cottus punctulatus (Gill).

About 30 specimens, measuring from 35 to 90 mm., were collected in Silver Creek, Harney County. The lateral line extends almost as far posteriorly as the base of soft dorsal, in some examples being quite complete. The body is entirely smooth in every case. Of 20 specimens examined 13 have the dorsals separate, the space between them sometimes being nearly as wide as that between two rays; 7 have the fins joined at their bases, the membrane, however, not extending upward on the first ray. Five individuals have 3 preopercular spines, while 15 have 4. In all cases the fourth spine is very minute. In 1 example with 3 spines the lowest is barely visible. The spines are sharper and more prominent on smaller individuals All have narrow bands of palatine teeth.

In many specimens the fourth ventral ray is small, occasionally being difficult to find. In one individual it is entirely absent. The apparent variability of this character, together with the fact that the specimens agree closely with the description of *Uranidea bendirei* (Bean)[a] has led to the supposition that the latter may belong to the genus *Cottus*, being nothing more than an example of *C. punctulatus* in which but 3 of the ventral rays are well developed.[b]

This species is very similar to *C. perplexus*, one of a series of 3 closely related forms extending southward in the coastwise rivers, at least to the Sacramento. They are *C. perplexus* of the Columbia, *C. klamathensis* of the Klamath, and *C. gulosus* of the Sacramento. Nothing is known of the distribution of these species in other basins than those mentioned.

TABLE SHOWING NUMBER OF SPINES OR RAYS IN THE FINS OF 20 SPECIMENS OF COTTUS PUNCTULATUS FROM SILVER CREEK, HARNEY COUNTY, OREG.

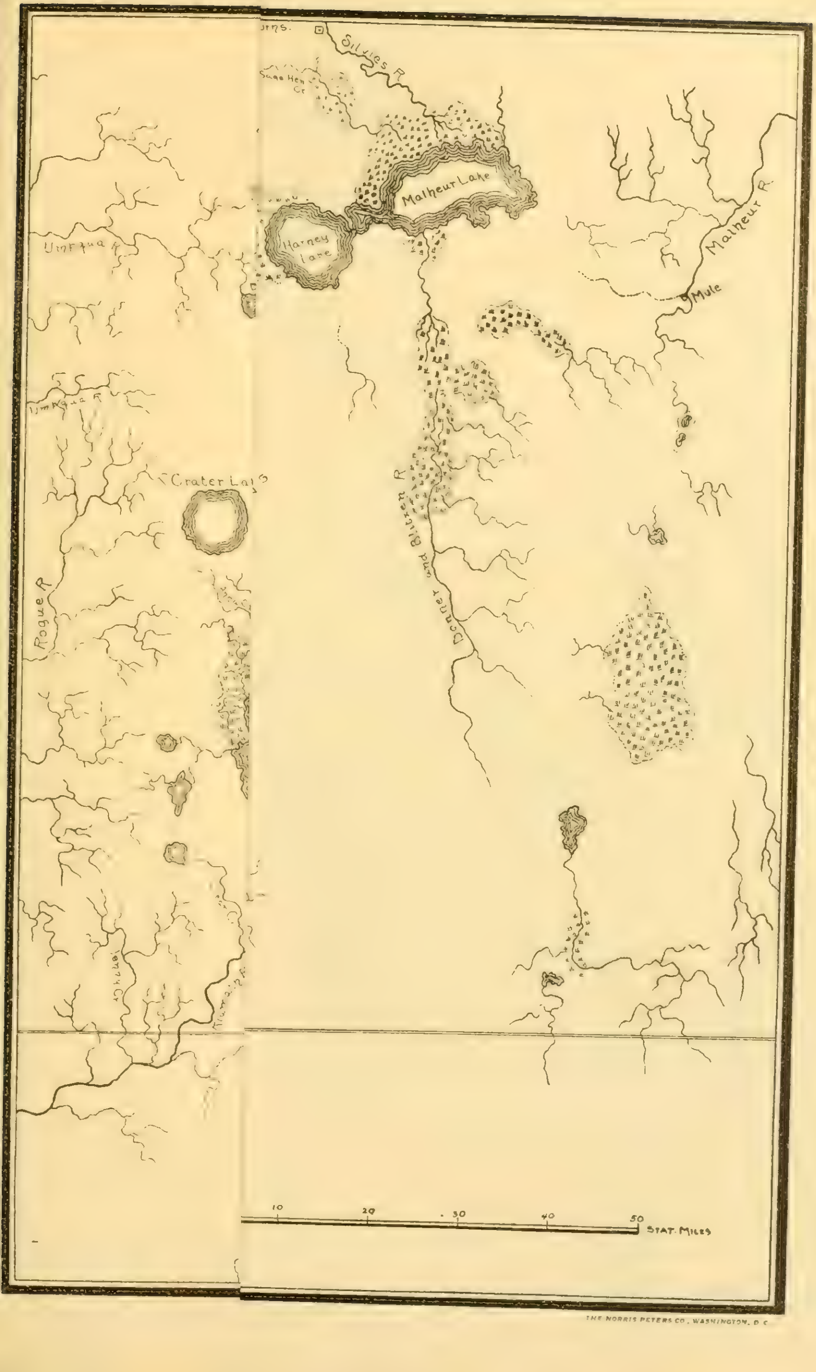
Spines or rays.	Specimens showing character.	Spines or rays.	Specimens showing character.
Spinous dorsal:		Anal—Continued.	
7	12	13	3
8	13	14	1
Soft dorsal:		Pectoral:	
15	8	13	1
16	15	14	5
17	2	15	14
Anal:		16	5
11	4		
12	17		

[a] Bean, T. H., Proc. U. S. National Museum, 1881, p. 27. *Potamocottus bendirei*, Rattlesnake Creek, near Camp Harney, Oreg.

[b] Writing in this connection Mr. B. A. Bean says: "I have examined the type of *Potamocottus bendirei* and find that the ventral of the right side has I, 3 +. The + is represented by a rudimentary ray showing through the skin, especially at the base. The left ventral has I, 3. I find no trace of a rudimentary ray."

MEASUREMENTS OF SPECIMENS OF COTTUS PUNCTULATUS FROM SILVER CREEK, HARNEY COUNTY, OREG.

Length body.....mm..	84	73	67	65	57	57	57	56	53	50
Length head	.35	.34	.33	.35	.34	.36	.355	.335	.35	.345
Depth body	.255	.235	.23	.23	.25	.245	.25	.24	.24	.24
Snout to dorsal	.38	.38	.38	.385	.38	.385	.39	.36	.37	.40
Snout to anal	.575	.60	.61	.59	.59	.59	.61	.58	.62	.61
Depth caudal peduncle	.085	.09	.09	.085	.095	.09	.085	.09	.09	.10
Length caudal peduncle	.15	.165	.15	.185	.15	.16	.14	.14	.15	.145
Length snout	.12	.095	.105	.11	.11	.105	.11	.12	.11	.11
Length maxillary	.175	.17	.165	.165	.15	.145	.15	.15	.15	.15
Diameter eye	.06	.075	.075	.075	.08	.085	.085	.08	.10	.08
Interorbital width	.06	.07	.05	.06	.06	.05	.05	.055	.05	.05
Depth head	.215	.215	.21	.21	.22	.225	.21	.22	.215	.21
Height spinous dorsal	.08	.085	.11	.09	.09	.10	.10	.095	.11	.10
Height soft dorsal	.13	.15	.15	.15	.14	.14	.15	.15	.14	.155
Height anal	.115	.14	.13	.15	.14	.135	.13	.13	.11	.14
Length pectoral	.26	.23	.29	.21	.28	.27	.26	.285	.26	.28
Length ventral	.16	.17	.14	.20	.19	.21	.15	.17	.16	.20
Length caudal	.23	.25	.245	.25	.24	.255	.225	.23	.23	.26
Number dorsal spines	8	8	8	7	8	7	7	8	8	7
Number dorsal rays	16	16	16	16	16	17	15	15	15	15
Number anal rays	12	12	13	11	12	12	12	12	12	11
Number pectoral rays	15	14	15	15	15	15	16	15	15	16



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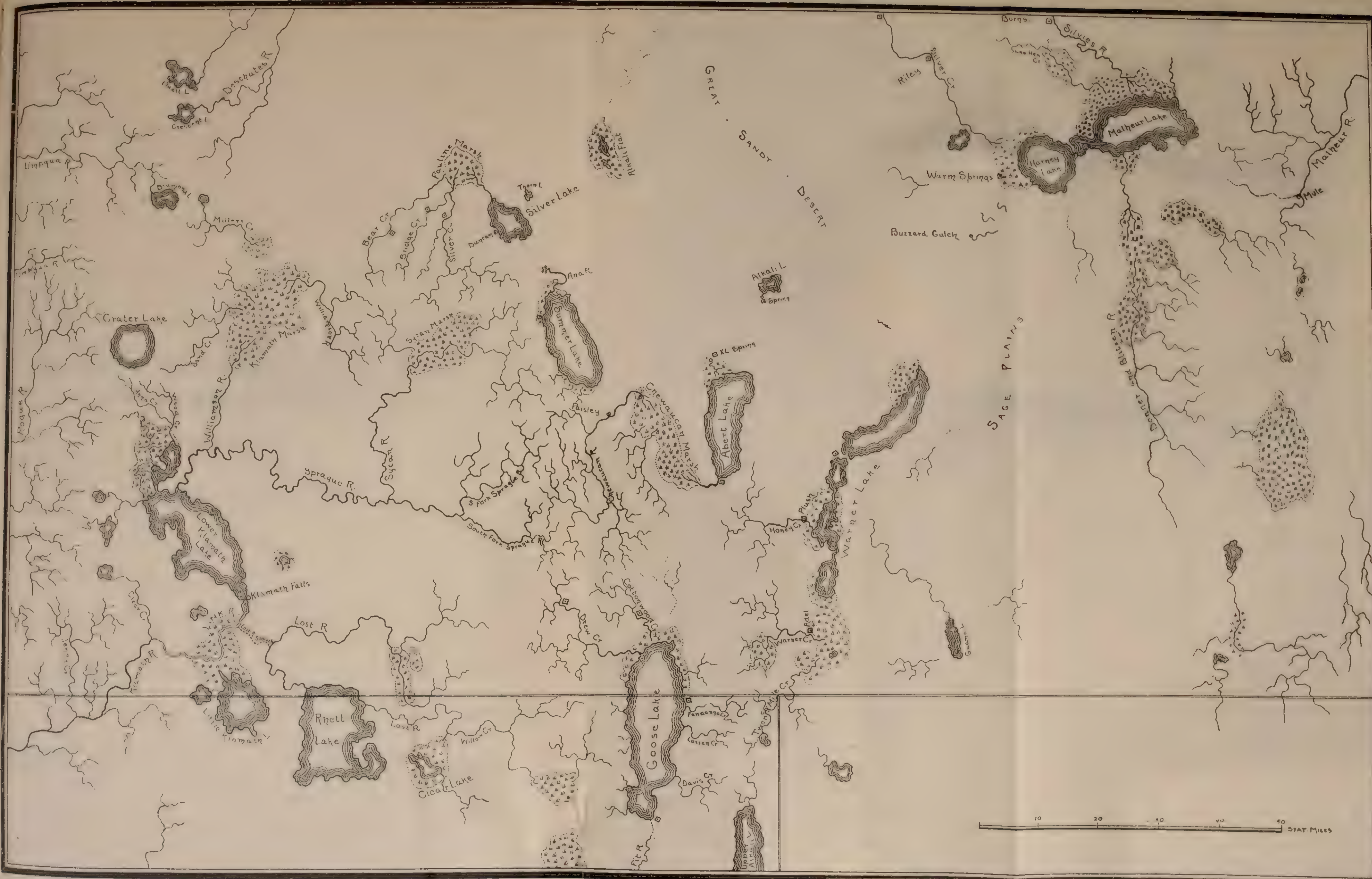


MAP OF THE LAKE REGION OF SOUTHEASTERN OREGON.

THE NORRIS PETERS CO., WASHINGTON, D.C.

THE FISHES OF THE SACRAMENTO-SAN JOAQUIN BASIN, WITH A STUDY OF THEIR DISTRIBUTION AND VARIATION

By CLOUDSLEY RUTTER

BUREAU OF FISHERIES DOCUMENT NO. 637

THE FISHES OF THE SACRAMENTO-SAN JOAQUIN BASIN, WITH A STUDY OF THEIR DISTRIBUTION AND VARIATION.

By CLOUDSLEY RUTTER.[a]

The following report embodies the results of studies conducted incidentally to an investigation of the natural history of the young salmon. The primary object was to determine the distribution of the various species of fishes found in the Sacramento-San Joaquin basin, but the identification of the species necessitated a study of their variations, which has proved of equal interest. The determinations are based on large collections made in 1898 and 1899 by the author with Mr. Fred M. Chamberlain, of the Bureau of Fisheries, Mr. N. B. Scofield, ichthyologist of the California Fish Commission, and Mr. W. S. Atkinson, a student at Stanford University, as associates.

The report includes notes on the geography of the basin, with a synopsis of the streams in which collections were made; a review of the various papers in which other collections from this region have been recorded; a key to the species known to inhabit the basin; detailed discussion of the variations and the local distribution of the native species; a list of the anadromous species; and a list of the species that have been introduced.

GEOGRAPHY OF THE BASIN.

The great central basin of California, drained by the Sacramento and San Joaquin rivers, has for its eastern rim the Sierra Nevada and for its western the coast ranges. Spurs from these two ranges form the southern boundary of the basin, and the ranges themselves meet at the north, culminating in Mount Shasta, and form the northern boundary. The outlet of the basin is through a notch in the middle of the western rim, occupied by San Pablo and San Francisco bays. The shape of the basin is that of a long ellipse, with its major axis curved concentric with the coast line. Its length is about 450 miles and its width about 125 miles. Altogether the Sacramento-San Joaquin basin, including Pitt River drainage but excluding Goose Lake and San Pablo and San Francisco bays and their immediate drainage, has an area of 58,250 square miles, which is greater by 1,600 square miles than the state of Illinois. Its northern

[a] The manuscript for this report, submitted by Mr. Rutter at the completion of the studies upon which it is based, had not, at the time of his death, in 1903, been arranged in final form for printing. The information it contains, however, is considered of interest and value, and the paper is accordingly presented with such revision as is possible under the circumstances, the modifications that have been made relating chiefly to the form and order in which the material is presented.

extremity lies in nearly the same latitude as Chicago and its southern in about that of Memphis, Tenn. The distance from either of the extreme river sources to the Golden Gate is nearly as great as that from Chicago to Cairo, Ill. The general direction of the San Joaquin, or southern portion of the basin, is southeast to northwest, that of the Sacramento portion nearly north to south.

Part of the table-land of northeastern California is drained by Pitt River, which cuts through the Sierra Nevada near the northern end of the range and joins the Sacramento in the foothills at the northern end of the valley. This adds a considerable area to the central drainage system. The tributaries draining the west side of the basin are small, and are dry in their lower courses for most of the year. The eastern tributaries are numerous and several of them are of considerable size. The larger tributaries of the Sacramento, named in the order of their size, are: (1) Pitt River, (2) Feather River, (3) McCloud River, and (4) Fall River (the latter two being tributaries of Pitt River), (5) Upper Sacramento (above mouth of Pitt River), (6) Battle Creek, and (7) American River. Those of the San Joaquin are (1) Kings, (2) Upper San Joaquin, (3) Merced, (4) Mokelumne, (5) Kern, (6) Tuolumne, and (7) Stanislaus rivers.

SYNOPSIS OF STREAMS.

Following is a list of the principal streams of the basin, italics indicating those in which collections have not been made. Smaller streams are mentioned if fishes have been reported from them. The tributaries are named in order, beginning with the lowest of the right bank drainage and going upstream and around the basin, coming down on the left bank. Secondary tributaries are named in the same order. The indentions indicate the relation of the various streams. When the particular point from which fishes have been reported is known, it is given after the name of the stream. If fishes have been reported from more than one point, the different stations are listed in order, beginning with the lower.

- Suisun Bay (Benicia, Martinez, Dutton).
- Sacramento River (Collinsville, Rio Vista, Ryde, Walnut Grove, mouth of American River, mouth of Feather River, Knights, 20 miles below Grimes, Wilson Farm, 4 miles above Grimes, Colusa, 5 miles below Princeton, Butte City, Jacinto, Chico, mouth of Deer Creek, mouth of Thomas Creek, Tehama, 6 miles below Red Bluff, Red Bluff, mouth of Battle Creek, near Fort Reading, mouth of Clear Creek, Redding).
  - Fresh-water lagoons (locality not stated).
  - Putah Creek.
    - Ætna Springs.
  - Cache Creek.
    - Clear Lake.
    - Allen Springs.
  - Stoney Creek.
  - Thomas Creek (at mouth).
  - *Elder Creek.*
  - *Red Bank Creek.*
  - Cottonwood Creek (Cottonwood).
  - Clear Creek (at mouth).
  - Upper Sacramento River (Sims, Dunsmuir, Sisson, at source).
    - Lake (near source of river).
  - Cliff Lake.

Sacramento River, etc.—Continued.
- Cedar Lake.
- Gumboot Lake (the source of Sacramento River).
- *North Fork Sacramento River.*
- Sullaway Creek (Sissons).
- Hazel Creek (near mouth).
- *Pitt River*, lower.
    - McCloud River (Baird, lower falls, Big Bend, Bartlets).
    - *Squaw Creek.*
    - Fall River (Fall River Mills, Dana, Bear Creek, on road from Bartlets to Dana).
- Pitt River, upper (Pittville, Bieber, Canby).
    - North Fork Pitt River (near Alturus, at mouth of Joseph Creek).
        - Goose Lake (several places: Davis Creek, Davis Creek P. O.).
        - Joseph Creek (at mouth).
        - *Packer Creek.*
    - South Fork Pitt River (South Fork P. O., Jesse Valley).
    - Ash Creek (Aden).
        - Rush Creek (on road from Aden to Canby).
    - *Beaver Creek.*
    - Hat Creek (Cassel).
    - Burney Creek (Burneyville).
    - Cow Creek (Fort Reading).
- Battle Creek (United States hatchery).
    - *North Fork.*
    - South Fork (Longs, Battle Creek Meadows).
    - *Antelope Creek.*
    - Mill Creek (Morgan Springs).
    - Deer Creek (at mouth).
    - *Chico Creek.*
- Feather River (Marysville, Oroville).
    - North Fork (Big Meadows, near source).
        - Warner Creek (Johnsons).
        - Duck Lake (near Big Meadows).
        - Indian Creek (Crescent Mills, Genesee Valley).
            - Wolf Creek (Greenville).
            - Squaw Queen Creek (at mouth).
            - Clover Creek (Clover Creek Canyon, lower edge of Clover Valley, upper edge of Clover Valley).
            - Spanish Creek (Quincy).
                - Gausner Creek (Quincy).
    - Middle Fork (Nelson Point, Beckwith).
        - *Sierra Valley Marshes.*
            - *Hamlin Creek.*
                - Cole or Bullin Creek (near source).
        - Gold Lake.
    - *South Fork.*
    - *Yuba River.*
        - North Fork (Bullards Bar).
            - Lower Salmon Lake.
            - Middle Salmon Lake.
            - Upper Salmon Lake.
            - Bassett Creek (Bassett Hotel).
        - *Middle Fork.*
        - *South Fork.*

Sacramento River, etc.—Continued.
- Feather River (Marysville, Oroville)—Continued.
  - *Bear River.*
    - Wolf Creek (near Grass Valley).
      - Rattlesnake Creek (near Grass Valley).
- *Coon Creek.*
  - South Fork of Dry Creek (near Auburn).
- *Dry Creek.*
- Antelope Creek (near Auburn).
- Secret Ravine (Rocklin).
- American River (Folsom).
  - Arcade Creek (Arcade).
  - *North Fork.*
  - *Middle Fork.*
    - Rubicon River (Gerlé, Rubicon Springs).
      - Miller Creek (Miller Pass).
  - South Fork (Placerville).
    - Silver Creek (near Orelli).
      - South Fork Silver Creek (Jones).

San Joaquin River (lower) (Black Diamond, Marsh Landing, Jersey Landing).
- *Mokelumne River.*
  - *Consumne River.*
    - North Fork (Pleasant Valley).
    - *South Fork.*
- *North Fork Mokelumne River.*
- Middle Fork Mokelumne River (West Point).
- South Fork Mokelumne River (Railroad Flat).
  - Licking Creek (near mouth?).
- Stockton Sloughs (locality not given).
- *Calaveras River.*
  - San Antonio Creek (near Calaveras Grove).
- *French Camp Creek.*
- Stanislaus River (Parrot Ferry).
- Tuolumne River (Modesto, Baker Ford).
  - *North Fork.*
  - *Middle Fork.*
  - *Upper Tuolumne River.*
  - South Fork (near mouth).
- Merced River (Livingston, Benton Mill).
  - North Fork (Bower Cave).
  - *South Fork.*
- *Bear Creek.*
- *Mariposa River.*
  - Mariposa Creek (Mariposa).
- Chouchilla River (near Raymond).
- Fresno River (near Raymond).
- Upper San Joaquin River (Pollasky, Fort Miller).
  - *South Fork San Joaquin River.*
- *Kings River.*
  - *North Channel* (near Centerville).
    - China Slough.
  - Middle Channel (near Centerville).
  - South Channel (near Centerville).
  - *Middle Fork Kings River.*
  - *South Fork Kings River.*

San Joaquin River, etc.—Continued.
- Kaweah River (Four Creeks).
  - St. Johns Channel (Lemon Cove).
- Tule River (Porterville).
- Poso Creek (near foothills).
- Kern Lake (of Tulare Valley).
  - Kern River (near Bakersfield).
    - Whitney Creek = Volcano Creek.
    - Kern Lake.
    - South Fork Kern River.
    - Caliente Creek.
- *Posa Chino Creek.*
  - *Los Gatos Creek.*
- *Big Panoche Creek.*
- *Los Banos Creek.*
- *Orestimber Creek.*
- Martinez Creek (hills back of Martinez).

DESCRIPTIVE NOTES.

The Sacramento River takes its rise in a group of small lakes in an elevated basin about 20 miles west of Sissons, Siskiyou County. The lakes are from 100 to 300 yards across and are separated by spurs of the mountains. On account of the heavy growth of timber and underbrush they are almost inaccessible. One, Cliff Lake, is deep; the others are quite shallow and evidently formed by glacial moraines. The shores of all are thickly strewn with fallen trees. The one known as Gumboot Lake lies farther to the westward and is the true source of the Sacramento River.

The river makes a rapid descent from the lakes to Box Canyon near Sissons, but there are no falls over 6 feet high. At the head of Box Canyon it receives Sullaway Creek, which is almost as large as the river itself at that point. It is in Sullaway Creek that the fry salmon from Sisson hatchery are planted.

The river continues in a narrow canyon almost to Redding, and is a typical mountain stream, a succession of rapids and pools. At Redding it leaves the mountains and passes through the foothills, becoming broader with fewer rapids. The last rapid of any moment is a few miles above Red Bluff, where the river cuts through a range of hills by what is known as Iron Canyon.

Below Iron Canyon the river becomes broader, though short rapids or riffles occur during the low water of summer. The current is swift throughout its length. Boats ascend as far as Red Bluff. The lower portion flows through a broad valley, and the floods from the winter rains have to be held in by levees. It is affected by the tides nearly 100 miles from its mouth, though the water is entirely fresh, as is also that of the upper portions of Suisun Bay into which the river empties.

The San Joaquin has much the same character as the Sacramento. The two rivers enter Suisun Bay side by side.

Pitt River is the largest tributary of the Sacramento, being much larger than the upper Sacramento. It is formed by the junction of the North and South Forks at Alturus, Modoc County.

North Fork of Pitt River rises immediately south of Goose Lake, and there is no doubt that in recent years it has drained the lake. The only barrier to the lake's drainage now is a gravel bank less than 8 feet high. This has evidently been formed

by ice bringing débris to the lower end of the lake, which it does even now, the lake, which is quite shallow, being less than 16 feet deep anywhere within 15 miles of the southern end.[a] On account of the evident recent connection between Goose Lake and Pitt River, as well as the identity of their faunas, the fishes of the lake are listed with those of the Sacramento–San Joaquin Basin.

North Fork of Pitt River, when seen in September, 1898, was a small stream, almost dry. There were a few pools where fishes lived, where even trout were found, but it was a very insignificant stream. A sawmill near its source fills the water with sawdust and doubtless does much damage to the fishes, though it is doubtful whether there are ever many valuable fishes in the stream.

South Fork of Pitt River is a larger stream, with pure water, but it is almost drained by irrigation ditches.

The upper Pitt River, above the mouth of Fall River, was nearly dry in August, 1898. What water it contained was of a slightly milky color. The rocks on the bottom were covered with a spongy slime. Such fishes as trout or salmon would not live in it at that time of year. This portion of the river traverses a high barren table-land. On the south are hills covered with sagebrush and scattered junipers; on the north are the lava beds known as the Devil's Garden. A hot spring is found near Canby, about 20 miles below Alturus.

At Fall River Mills, Pitt River receives Fall River, a stream about 100 feet wide and 4 feet deep, with a strong current, but only about 15 miles long. Fall River takes its rise in two or three large springs near Dana, and flows several times as much water as Pitt River above their union. The water is clear and cool and the bottom gravelly, making an excellent spawning stream for salmon, but difficult to attain on account of the steep rapid at its mouth as well as the fall in Pitt River.

Above the mouth of Fall River for a few miles, Pitt River is broad and deep, but without any perceptible current. Below the mouth of Fall River its character changes entirely. It is broad but shallow, very swift, with many rapids, and makes a rapid descent to the falls. Pitt River Falls, which are 65 feet high, are thought by many to rival in beauty any to be seen in the Yosemite Valley. The middle portion is a sheer fall, but each side is broken by ledges, so that it is possible in high water for fish to pass. A fish ladder has been blasted out of the rock near the left bank, and salmon now go over the falls in considerable numbers.

From the falls to its junction with the Sacramento a few miles above Redding, Pitt River has much the same character as the upper Sacramento, but is a much larger stream. A few miles below the falls Pitt River receives Hat Creek and Burney Creek. The former is a salmon stream of some importance, but it has a number of rapids that make its ascent difficult. Burney Creek has a fall near its mouth about 180 feet high.

McCloud River is the largest tributary of Pitt River. It is a clear and cool stream, twice the size of the upper Sacramento, and receives the southern and eastern drainage of Mount Shasta. There are three falls in the middle portion of

[a] The above statements concerning Goose Lake are made on the authority of several persons living near its southern end, some claiming that the barrier is only 3 feet high. In the account of the explorations of the Wheeler Survey in 1877, the following statement is made: "Goose Lake is merely a sink, as it has not run out by its old outlet, Pitt River, for many years. From the best evidence I could obtain, I found that it did run out through the river eight years ago [1869]."

the river, the lowest being 12 feet high. Adult salmon were seen immediately below this fall, but it is said that none pass it. McCloud River is an important salmon stream, and a government hatchery is situated at Baird, about 2 miles above its mouth.

Battle Creek is a swift mountain stream, rising by two branches and draining the western slope of Lassen Buttes. It empties into the Sacramento about midway between Redding and Red Bluff. It is the most important salmon stream of the basin, and a government hatchery is located at its mouth.

Feather River, next to Pitt River, is the largest tributary of the Sacramento. It drains the region between Lassen Buttes and Truckee, and is formed by the union of several secondary tributaries.

Duck Lake lies just west of Big Meadows and is tributary to North Fork of Feather River. It is a shallow lake, but is an important breeding place for trout.

Gold Lake lies high in the mountains east of Sierra Valley and is tributary to Middle Fork of Feather River. There are many other lakes in the vicinity, the more important being the Salmon Lakes and Sardine Lakes, tributary to a branch of Yuba River. They are so named from the salmon-colored trout found in the one and the small size of the trout found in the other.

The name Basset Creek is here used for the first time, designating the branch of North Fork of Yuba River whose course is followed by the Sierraville–Sierra City stage road.

American River drains the mountains west and south of Lake Tahoe and empties into the Sacramento near the city of Sacramento. It is almost dry in its lower course during the summer. The streams farther south, the Mokelumne, Stanislaus, Merced, and upper San Joaquin, are similar to the American, but larger. They rise near the crest of the Sierras, are formed by the union of north, middle, and south forks, flow at right angles to the San Joaquin, into which they empty, and have but little water in their lower courses during the summer.

North Fork of Merced River is separated from the main Merced River by a 12-foot fall. Mariposa Creek is a mere brook that during the summer empties into the dry bed of Mariposa River. Chouchilla and Fresno rivers are small streams that are lost in the sand long before they reach the San Joaquin.

Kings, Kaweah, Tulle, and Kern rivers drain the west slope of the southern portion of the Sierras. Their water hardly ever, or never, reaches the San Joaquin, being used largely for irrigation.

Tulare Lake, which at one time furnished fish to San Francisco markets, is now dry.

Two Kern Lakes have been recognized by collectors. One is in Tulare Valley and receives the drainage of Kern River during the rainy season; the other is an enlargement of the channel of Kern River near Mount Whitney, just below the mouth of Volcano Creek.

BIBLIOGRAPHICAL REVIEW.

The following bibliography includes all known records for this basin, with the names of the collectors wherever possible. Species recorded as new are distinguished in the tabulated lists by means of italics. A synonymy which includes the reference to the original description, a reference to each synonym that has been applied

to specimens reported from this territory, and page references to Jordan & Evermann's Fishes of North and Middle America, is given at the head of the notes on each species, in the later portion of the paper.

AGASSIZ, ALEXANDER.

1861–62. Notes on the described species of Holconoti found on the western coast of North America. Proceedings of the Boston Society of Natural History, vol. VIII, 1861–62, p. 122–133.

The paper is chiefly a list of synonyms, to which the author adds another, giving as his excuse that certain specimens had been so labeled and that doubtless other specimens similarly labeled had been sent to other museums. *Hysterocarpus traski* and *Sargosomus fluviatilis* (given as a synonym) are recorded (p. 130) from the Sacramento region. Both are now identified as *Hysterocarpus traskii.*

AGASSIZ, LOUIS.

1855. Synopsis of the ichthyological fauna of the Pacific slope of North America, chiefly from the collections made by the United States Exploring Expedition under the command of Capt. C. Wilkes, with recent additions and comparisons with eastern types. American Journal of Science and Arts, 1855, p. 71–99 and p. 215–231.

The author makes an extensive study of the genera of suckers and minnows. He noted only two of his species, *Catostomus occidentalis* and *Ptychocheilus major,* in the Sacramento-San Joaquin basin, and both of these he described as new. *Catostomus occidentalis,* however, had but a few weeks previously been described under the same name by Ayres. *Ptychocheilus major* (p. 229) is the present *P. grandis.* Agassiz's specimens were collected by F. G. Cary, jr.

AYRES, W. O.

1854a. Daily Placer Times and Transcript, May 30, 1854. Five new species are described, all of them collected by Dr. Ayres in the San Francisco markets. The paper is reviewed by Dr. Jordan in Proceedings of the U. S. National Museum for 1880, p. 325-327.

Species as reported.	Present identification.
Leuciscus *gibbosus*	Leuciscus crassicauda.
Leuciscus *microlepidotus*	Orthodon microlepidotus.
Leuciscus *gracilis*	Ptychocheilus grandis.
Leuciscus *macrolepidotus*	Pogonichthys macrolepidotus.
Catostomus *occidentalis*	Catostomus occidentalis.

1854b. New species of California fishes. Proceedings of the Boston Society of Natural History, vol. v, 1854, p. 94–103.

Describes on page 99 *Centrarchus maculosus,* now identified as *Archoplites interruptus.* Based on his own collections.

1854–57. Proceedings California Academy of Natural Sciences, vol. I, 1854–57.

In this volume appear a number of descriptions of fishes submitted by Dr. Ayres at various times. He had already described four of these species in the Daily Placer Times and Transcript, but lists them in the Academy Proceedings as if they were new, and to one, *Leuciscus gracilis,* he gives a new name, *Gila grandis.* The work is based on his own collections and specimens of trout collected by Dr. Winslow.

Page.	Species as reported.	Present identification.
8	Centrarchus maculosus	Archoplites interruptus.
18	Catostomus occidentalis	Catostomus occidentalis.
18	Gila *grandis*	Ptychocheilus grandis.
20	Lavinia gibbosa	Leuciscus crassicauda.
21	Lavinia *compressa*	Lavinia exilicauda.
21	Gila microlepidota	Orthodon microlepidotus.
32	Catostomus *labiatus*	Catostomus occidentalis.
33	Mylopharodon *robustus*	Mylopharodon conocephalus.
43	Salmo *rivularus*	Salmo irideus.
44	Petromyzon *ciliatus*	Entosphenus tridentatus.
47	Gasterosteus *serratus*	Gasterosteus cataphractus.
47	Gasterosteus microcephalus	Gasterosteus cataphractus.
47	Gasterosteus plebeus	Gasterosteus cataphractus.

BEAN, TARLETON H.

1880. Check list of duplicates of North American fishes distributed by the Smithsonian Institution in behalf of the United States National Museum, 1877–1880. Proceedings of the U. S. National Museum, 1880, p. 75–116.

Page.	Species as reported.	Present identification.
106	Salmo irideus	Salmo irideus.
106	Oncorhynchus quinnat	Oncorhynchus tschawytscha.
107	Salvelinus bairdii	Salvelinus malma.

COPE, EDWARD D.

1883. On the fishes of the Recent and Pliocene lakes of the western part of the Great Basin and of the Idaho Pliocene lake. Proceedings of the Academy of Natural Sciences of Philadelphia, 1883, p. 134–165.

In addition to the list of species are given notes on the geography and geology of the region, with a map. Collections by himself.

Page.	Species as reported.	Present identification.
143	Myloleucus parovanus	Rutilus bicolor.
144	Myloleucus *thalassinus*	Rutilus bicolor.
150	Catostomus labiatus	Catostomus occidentalis.

EIGENMANN, C. H., and EIGENMANN, R. S.

1889a. Fishes of Ætna Springs, Napa County, Cal. West American Naturalist, 1889, p. 149.

Describes from this region (p. 149) *Phoxinus clevelandi*, later identified as *Leuciscus egregius*. Collected by D. Cleveland.

1889b. Fishes of Allen Springs, Lake County, California. West American Naturalist, 1889, p. 149. Collector, D. Cleveland.

Page.	Species as reported.	Present identification.
149	Ptychocheilus oregonensis	Ptychocheilus grandis.
149	Salmo irideus	Salmo irideus.
149	Uranidea semiscaber *centropleura*	Cottus gulosus.

EIGENMANN, C. H., and ULREY, ALBERT B.

1892. A review of the Embiotocidæ. Bulletin U. S. Fish Commission, vol. XII, 1892, p. 382–400.

Gives a complete synonymy for each species of the family. Records (p. 399) *Hysterocarpus traskii* from this region.

GIBBONS, W. P.

1854a. Descriptions of new species of viviparous fishes from Sacramento River and the Bay of San Francisco. Daily Placer Times and Transcript, May 18, 1854.

Among the descriptions here given is the first description of new species based on specimens from Sacramento basin. Only one species, *Hystrocarpus traskii*, came within our notice. Collected by a Mr. Morris, and forwarded by Dr. J. B. Trask. Locality not given.

1854b. Description of new species of viviparous fishes from Sacramento River and the Bay of San Francisco. Proceedings Academy of Natural Sciences of Philadelphia, 1854, p. 105–106.

One fresh-water species described (p. 105), with a form called "var. B." This is *Hystrocarpus traskii*, which had been previously described in the Daily Placer Times and Transcript May 18, 1854.

1854c. Description of new species of viviparous marine and fresh-water fishes from the Bay of San Francisco, and from the river and lagoons of the Sacramento. Proceedings Academy of Natural Sciences of Philadelphia, 1854, p. 122–126.

Describes several new genera and species, among which is the genus *Hysterocarpus* (p. 124). *Hysterocarpus traskii* is redescribed, the variation called "var. A" instead of "var. B," as on page 105.

GILL, THEODORE.

1862. Note on some genera of fishes of western North America. Proceedings of the Academy of Natural Sciences of Philadelphia, 1862, p. 329–332.

A list of names without localities. The only point in which this paper touches the present report is in furnishing (p. 331) an additional synonym for one of the lampreys. This is a name merely, without description or locality—*Entosphenus epihexodon*, now *Entosphenus tridentatus*.

GIRARD, CHARLES.

1854. Description of new fishes collected by Dr. A. L. Heermann, naturalist attached to the survey of the Pacific Railroad route, under Lieut. R. S. Williamson, U. S. A. Proceedings Academy of Natural Sciences of Philadelphia, 1854, p. 129–140.

Page.	Species as reported.	Present identification.
129	Centrarchus *interruptus*	Archoplites interruptus.
129	Cottopsis *gulosus*	Cottus gulosus.
133	Gasterosteus *microcephalus*	Gasterosteus cataphractus.
135	Gila *conocephala*	Mylopharodon conocephalus.
136	Pogonichthys *inæquilobus*	Pogonichthys macrolepidotus.
136	Pogonichthys *symmetricus*	Rutilus symmetricus.
137	Lavinia *exilicauda*	Lavinia exilicauda.
137	Lavinia *crassicauda*	Leuciscus crassicauda.
137	Lavinia *conformis*	Leuciscus conformis.
137	Leucosomus *occidentalis*	Rutilus symmetricus.

1856. Researches upon the cyprinoid fishes inhabiting the fresh waters of the United States of America west of the Mississippi Valley, from specimens in the Museum of the Smithsonian Institution. Proceedings of the Academy of Natural Sciences of Philadelphia, 1856, p. 165–209.

Page.	Species as reported.	Present identification.
169	Mylopharodon conocephalus	Mylopharodon conocephalus.
169	Mylopharodon robustus	Mylopharodon conocephalus.
174	Catostomus occidentalis	Catostomus occidentalis.
182	Orthodon microlepidotus	Orthodon microlepidotus.
183	Algansea *bicolor*	Rutilus bicolor.
183	Algansea *formosa*	Rutilus symmetricus.
184	Lavinia exilicauda	Lavinia exilicauda.
188	Pogonichthys inæquilobus	Pogonichthys macrolepidotus.
188	Pogonichthys symmetricus	Rutilus symmetricus.
206	Tigoma conformis	Leuciscus conformis.
207	Tigoma *crassa*	Leuciscus crassicauda.
208	Siboma crassicauda	Leuciscus crassicauda.
209	Ptychocheilus grandis	Ptychocheilus grandis.

1857. In Pacific Railway Survey Reports, vol. x, Zoological report no. 4, 1857.

Under Lieut. E. G. Beckwith's report of the survey of the 38th and 39th parallel, on the fishes collected, are listed (p. 23) *Lavinia exilicauda* and *Pogonichthys inæquilobus* (now *P. macrolepidotus*) from the Sacramento River. Collected by Dr. A. L. Heermann.

1857. In Pacific Railway Survey Reports, vol. vi, 1857, pt. iv, Zoological report no. 1.

Under Lieut. Henry L. Abbot's report of explorations for a railway from the Sacramento Valley to the Columbia River, among the fishes recorded are the following from the Sacramento basin. Collected by Dr. J. S. Newberry, with assistance of Dr. J. F. Hammond.

Page.	Species as reported.	Present identification.
9	Ambloplites interruptus	Archoplites interruptus.
10	Cottopsis gulosus	Cottus gulosus.
26	Hysterocarpus traskii	Hysterocarpus traskii.
27	Mylopharodon robustus	Mylopharodon conocephalus.
28	Catostomus occidentalis	Catostomus occidentalis.
28	Orthodon microlepidotus	Orthodon microlepidotus.
29	Lavinia exilicauda	Lavinia exilicauda.
30	Tigoma crassa	Leuciscus crassicauda.
31	Ptychocheilus grandis	Ptychocheilus grandis.
33	Salar iridea	Salmo irideus.

GIRARD, CHARLES—Continued.

1858. Pacific Railway Survey Reports, vol. x, pt. iv, Fishes, 1858.

Most of the new species had been previously described in various papers. Twenty-one nominal species are recorded from the Sacramento-San Joaquin basin. The collections were made by Dr. Heermann, Dr. Newberry, Dr. Kennerly, and Dr. Hammond, as indicated specifically in subsequent pages of this paper.

Page.	Species as reported.	Present identification.
10	Amblopliter interruptus	Archoplites interruptus.
53	Cottopsis gulosus	Cottus gulosus.
54	Cottopsis parvus	Cottus asper.
91	Gasterosteus microcephalus	Gasterosteus cataphractus.
190	Hysterocarpus traskii	Hysterocarpus traskii.
216	Mylopharodon conocephalus	Mylopharodon conocephalus.
216	Mylopharodon robustus	Mylopharodon conocephalus.
224	Catostomus occidentalis	Catostomus occidentalis.
[illegible]	Orthodon microlepidotus	Orthodon microlepidotus.
[illegible]	Algansea formosa	Rutilus symmetricus.
241	Lavinia exilicauda	Lavinia exilicauda.
245	Pogonichthys inæquilobus	Pogonichthys macrolepidotus.
246	Pogonichthys symmetricus	Rutilus symmetricus.
280	Luxilus occidentalis	Lavinia exilicauda.
[illegible]	Tigoma conformis	Leuciscus conformis.
[illegible]	Tigoma crassa	Leuciscus crassicauda.
[illegible]	Siboma crassicauda	Leuciscus crassicauda.
[illegible]	Ptychocheilus grandis	Ptychocheilus grandis.
321	Salar iridea	Salmo irideus.
377	Petromyzon tridentatus	Entosphenus tridentatus.
378	Petromyzon ciliatus	Entosphenus tridentatus.

1859a. In Pacific Railway Survey Reports, vol. x, pt. vi, Zoological report no. 5, 1859.

In Lieutenant Whipple's report of the survey of the 35th parallel is recorded (p. 47) the occurrence of *Ambloplites interruptus*, now *Archoplites interruptus*. Collector Dr. C. B. Kennerly.

1859b. In Pacific Railway Survey Reports, vol. x, Zoological report no. 4.

In the report of the survey near the 32d parallel the following species are recorded from the Sacramento-San Joaquin basin. Collector Dr. A. L. Heermann.

Page.	Species as reported.	Present identification.
83	Ambloplites interruptus	Archoplites interruptus.
84	Cottopsis gulosus	Cottus gulosus.
85	Gasterosteus microcephalus	Gasterosteus cataphractus.
88	Mylopharodon robustus	Mylopharodon conocephalus.
88	Mylopharodon conocephalus	Mylopharodon conocephalus.
88	Algansea formosa	Rutilus symmetricus.
89	Lavinia exilicauda	Lavinia exilicauda.
89	Pogonichthys inæquilobus	Pogonichthys macrolepidotus.
89	Pogonichthys symmetricus	Rutilus symmetricus.
89	Luxilus occidentalis	Lavinia exilicauda.
90	Tigoma conformis	Leuciscus conformis.
90	Tigoma crassa	Leuciscus crassicauda.
90	Siboma crassicauda	Leuciscus crassicauda.

JORDAN, DAVID STARR.

1878. A synopsis of the family Catostomidæ. Bulletin 12, U. S. National Museum, 1878, p. 97–237.

A comprehensive review, with localities, synonymy, bibliography, and index. Describes a nominal species from this basin, *Catostomus arcopus* (p. 173), and reports *Catostomus occidentalis* (p. 172). *C. arcopus* is now identified with *C. occidentalis*.

1892. A description of the golden trout of Kern River, California. Proceedings of the U. S. National Museum, 1892, p. 481.

Reports, on page 481, *Salmo mykiss aqua-bonita*, now called *Salmo irideus aqua-bonita*, collected in Whitney Creek by "Mr. Harvey, of Lone Pine, Cal."

JORDAN, DAVID STARR—Continued.

1894. Descriptions of new varieties of trout. Thirteenth Biennial Report of the California Fish Commission 1894, p. 142–143, with plates of each species described. Collections by C. H. Gilbert, 1893, and by Livingston Stone at various times.

Page.	Name as reported.	Present identification.
142	Salmo irideus *stonei*	Salmo irideus.
142	Salmo gairdneri *shasta*	Salmo irideus.
143	Salmo gairdneri *gilberti*	Salmo irideus.

1896. Notes on fishes little known or new to science. Proceedings of the California Academy of Science, 1896, p. 201–244.

Describes *Cottus shasta* Jordan & Starks, which is now identified as *Cottus gulosus*. Collected by E. C. Starks in McCloud River, 1894.

JORDAN, D. S., and GILBERT, C. H.

1881. Notes on the fishes of the Pacific coast of the United States. Proceedings of the U. S. National Museum, 1881, p. 29–70. Collector, Livingston Stone.

Page.	Species as reported.	Present identification.
38	Salmo irideus	Salmo irideus.
38	Salmo gairdneri	Salmo gairdneri.
39	Oncorhynchus chouicha	Oncorhynchus tschawytscha.
39	Oncorhynchus gorbuscha	Oncorhynchus gorbuscha.
51	Hysterocarpus traski	Hysterocarpus traskii.
69	Gasterosteus microcephalus	Gasterosteus cataphractus.

1881. Description of a new species of Ptychocheilus (Ptychocheilus harfordi) from Sacramento River. Proceedings of the U. S. National Museum, 1881, p. 72–73.

Describes on page 72 *Ptychocheilus harfordi*, now identified as *P. grandis*.

1894. List of the fishes inhabiting Clear Lake, California. Bulletin U. S. Fish Commission, vol. xiv, 1894, p. 139–140. Collections by the authors.

Page.	Species as reported.	Present identification.
139	Entosphenus tridentatus	Entosphenus tridentatus.
139	Catostomus occidentalis	Catostomus occidentalis.
139	Lavinia exilicauda	Lavinia exilicauda.
139	Orthodon microlepidotus	Orthodon microlepidotus.
139	Leuciscus crassicauda	Leuciscus crassicauda.
139	Ptychocheilus oregonensis	Ptychocheilus grandis.
139	Ptychocheilus harfordi	Ptychocheilus grandis.
139	Pogonichthys macrolepidotus	Pogonichthys macrolepidotus.
139	Salmo mykiss irideus	Salmo irideus.
140	Gasterosteus microcephalus	Gasterosteus cataphractus.
140	Archoplites interruptus	Archoplites interruptus.
140	Cottus gulosus	Cottus gulosus.
140	Hysterocarpus traski	Hysterocarpus traskii.
140	Cyprinus carpio	Cyprinus carpio.
140	Ameiurus nebulosus	Ameiurus nebulosus.
140	Ameiurus catus	Ameiurus catus.
140	Micropterus dolomieu	Micropterus dolomieu.

JORDAN, D. S., and HENSHAW, H. W.

1878. Annual Report U. S. Geological Survey, 1878, app. NN, p. 187–205, Wheeler Survey, Zoology, Report of the fishes collected. H. W. Henshaw, collector.

Page.	Species as reported.	Present identification.
188	Catostomus areopus	Catostomus occidentalis.
193	Leucos formosus	Rutilus symmetricus.
194	Salmo irideus	Salmo irideus.
196	Salmo tsuppitch	Salmo irideus.
197	Salmo henshawi	Salmo irideus.
198	Salmo pleuriticus	Salmo irideus.
199	Ambloplites interruptus	Archoplites interruptus.
199	Uranidea gulosa	Cottus gulosus.

JORDAN, D. S., and JOUY, PIERRE L.

1881. Check list of duplicate fishes from the Pacific coast of North America, distributed by the Smithsonian Institution in behalf of the United States National Museum. Proceedings of the U. S. National Museum, 1881, p. 1–18.

Page.	Species as reported.	Present identification.
1	Gasterosteus microcephalus	Gasterosteus cataphractus.
5	Cottopsis gulosus	Cottus gulosus.
5	Cottopsis asper	Cottus asper.
10	Hysterocarpus traski	Hysterocarpus traskii.
12	Archoplites interruptus	Archoplites interruptus.
14	Salmo irideus	Salmo irideus.
14	Oncorhynchus kisutch	Oncorhynchus kisutch.
14	Oncorhynchus chouicha	Oncorhynchus tschawytscha.
15	Orthodon microlepidotus	Orthodon microlepidotus.
15	Squalius gibbosus	Leuciscus crassicauda.
15	Ptychocheilus oregonensis	Ptychocheilus grandis.
15	Ptychocheilus harfordi	Ptychocheilus grandis.
16	Pogonichthys macrolepidotus	Pogonichthys macrolepidotus.
16	Mylopharodon conocephalus	Mylopharodon conocephalus.
16	Catostomus occidentalis	Catostomus occidentalis.
16	Amiurus catus	Ameiurus catus.

LOCKINGTON, W. N.

1878–9. Report upon the food fishes of San Francisco. Report of the California Fish Commission, 1878–9, p. 17–58.

Lists the food fishes observed by the author in the San Francisco markets, excepting the salmon, giving notes and descriptions. At the close of the report is a table giving the relative abundance of the various fishes during each of the 12 months ending September 30, 1879. The following are listed from the Sacramento-San Joaquin basin.

Page.	Species as reported.	Present identification.
21	Archoplites interruptus	Archoplites interruptus.
50	Gila grandis	Ptychocheilus grandis.
50	Pogonichthys inæquilobus	Pogonichthys macrolepidotus.
50	Orthodon microlepidotus	Orthodon microlepidotus.
50	Siboma crassicauda	Leuciscus crassicauda.
50	Lavinia exilicauda	Lavinia exilicauda.
50	Catostomus occidentalis	Catostomus occidentalis.

KEY TO THE FISHES OF THE SACRAMENTO BASIN.

A. Body eel-shaped, no lower jaw. Lampreys.
B. Supra-oral lamina with 3 teeth, the middle one large. Size large. Anadromous lamprey. ENTOSPHENUS TRIDENTATUS
BB. Supra-oral lamina with a tooth at each end, none or a very small one in middle. Size small. Brook lamprey .... LAMPETRA CIBARIA
AA. Body not eel-shaped; lower jaw present.
C. Skin smooth or covered with prickles.
D. Dorsal and pectoral fins each with a strong spine. Catfishes .... AMEIURUS
E. Caudal fin truncate or rounded .... AMEIURUS NEBULOSUS
EE. Caudal fin forked or deeply emarginate .... AMEIURUS CATUS
DD. Pectoral fin without spines.
F. Ventral rays I, 4 .... COTTUS
G. Skin entirely asperate .... COTTUS ASPER
GG. Skin smooth except for a patch of prickles behind pectorals .... COTTUS GULOSUS
GGG. Skin entirely smooth.
H. Eye large, .3 of head .... COTTUS MACROPS
HH. Eye smaller, less than .3 of head .... COTTUS BELDINGII
FF. Ventral rays I, 3 .... COTTUS ASPERRIMA
CC. Sides crossed by a few vertical bony plates .... GASTEROSTEUS CATAPHRACTUS
CCC. Body scaly.
I. No teeth in mouth.
J. Lips very large and covered with coarse papillæ. Suckers.
K. Edges of jaws with hard cartilaginous sheaths; a notch at corner of mouth between upper and lower lips .... PANTOSTEUS LAHONTAN
KK. Mouth and lips not as above .... CATOSTOMUS
L. Fontanelle almost obliterated in specimens 6 inches long CATOSTOMUS MICROPS
LL. Fontanelle large.
M. Dorsal with 10 or 11 rays; scales small, 80 to 95 in lateral line CATOSTOMUS TAHOENSIS
MM. Dorsal with 12 to 14 rays, scales larger, 60 to 80 in lateral line CATOSTOMUS OCCIDENTALIS
JJ. Lips not large nor papillose.
N. Anal fin short (in species here considered), with fewer than 15 rays. Minnows.
O. Dorsal with a serrated spine .... CYPRINUS CARPIO
OO. Dorsal without spine. Native minnows.
P. Scales very fine, over 100 in lateral line. ORTHODON MICROLEPIDOTUS
PP. Fewer than 100 scales in lateral line.
Q. Upper lip with a frenum .... MYLOPHARODON CONOCEPHALUS
QQ. Upper lip without frenum.
R. Mouth large, maxillary extending to below eye; large pike-like fishes .... PTYCHOCHEILUS GRANDIS
RR. Mouth small, body more or less compressed.
S. Pharyngeal teeth in two rows .... LEUCISCUS
T. Tail very deep.
U. Anal with 8 or 9 rays, tail much compressed LEUCISCUS CRASSICAUDA
UU. Anal with 10 or 11 rays, tail not so much compressed LEUCISCUS CONFORMIS

TT. Tail more slender, sides with a red stripe. Size about 4 inches..........................LEUCISCUS EGREGIUS

SS. Pharyngeal teeth in one row.

V. Body much compressed, anal rays 11 or 12 LAVINIA EXILICAUDA

VV. Body but little compressed. Anal rays about 8.

W. Pharyngeal teeth 5–5 or 4–5...............RUTILUS

X. Body more compressed, tail heavier, its depth about .12 of body length......RUTILUS BICOLOR

XX. Body more nearly round; tail more slender, about .09 of body......RUTILUS SYMMETRICUS

WW. Pharyngeal teeth 4–4. Small fishes, less than 4 inches long.................AGOSIA ROBUSTA

NN. Anal fin with about 20 rays. Shad...............ALOSA SAPIDISSIMA

II. Jaws with teeth.

a. Adipose fin present, fins without spines.

b. Scales small, over a hundred in lateral line. Salmons and trouts.

c. Anal fin with 14 to 17 rays.................................ONCORHYNCHUS

d. Scales very fine, over 200 cross series above lateral line ONCORHYNCHUS GORBUSCHA

dd. Scales larger, 138 to 155 cross series, pyloric cœca about 150.

e. Anal 13 or 14, black spots obsolete, branchiostegals 13 or 14 ONCORHYNCHUS KETA

ee. Anal 16, back and upper fins with smaller black spots, branchiostegals 15 to 19 ..........................ONCORHYNCHUS TSCHAWYTSCHA

ddd. Scales large, 125 to 135 cross series, pyloric cœca 50 to 80 ONCORHYNCHUS KISUTCH

cc. Anal fin with 9 to 12 rays.

f. Scales 115 to 175.................................SALMO IRIDEUS

ff. Scales about 240..............................SALVELINUS MALMA

bb. Scales large, about 70 in lateral line................OSMERUS THALEICHTHYS

aa. No adipose fin; dorsal and anal with spines.

g. Scales cycloid; viviparous...............HYSTEROCARPUS TRASKII

gg. Scales ctenoid; oviparous.

h. Side of body without longitudinal stripes ARCHOPLITES INTERRUPTUS

hh. Side of body with longitudinal stripes.......ROCCUS LINEATUS

NATIVE FRESH-WATER SPECIES.

1. **Entosphenus tridentatus** (Gairdner). *Lamprey*.

Petromyzon tridentatus Gairdner, in Richardson, Fauna Boreali-Americana, p. 293, 1836, Falls of the Willamette.
Petromyzon ciliatus Ayres, Proc. Cal. Ac. Sci., 1855, p. 44, San Francisco.
Entosphenus ciliatus Gill, Proc. Ac. Nat. Sci. Phila., 1862, p. 331, San Francisco.
Entosphenus epihexodon Gill, Proc. Ac. Nat. Sci. Phila., 1862, p. 331, Fort Reading.
Lampetra, sp. incert., Jordan & Henshaw, Wheeler Survey, Report U. S. Geological Survey, 1878, p. 187, Goose Lake.
Entosphenus tridentatus, Jordan & Evermann, Fishes of North and Middle America, Bulletin 47, U. S. Nat. Mus., p. 13, 1896.

This is an anadromous species that has become landlocked in Goose Lake and Clear Lake. A specimen 7 inches long from Goose Lake has the fringe of the buccal disk a little heavier than a specimen of the same length from Pacific Grove; otherwise the two can not be distinguished. Jordan & Henshaw's larval *Lampetra* from Goose Lake was doubtless this species.

The adults can be distinguished from *Lampetra cibaria* by the presence of a tooth in the middle of the supra-oral lamina in addition to one at each end.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
San Francisco		Ayres	Petromyzon ciliatus	Ayres, 1854–1857.
do	San Francisco Bay	do	do	Girard, 1858.
Sissons	Sullaway Creek	Rutter & Chamberlain	Entosphenus tridentatus	
	Goose Lake	Henshaw	Lampetra sp	Jordan & Henshaw.
		Rutter & Chamberlain	Entosphenus tridentatus	
South Fork post-office.	South Fork Pitt River.	do	do	
Fort Redding	Cow Creek	Heermann	Petromyzon tridentatus	Girard, 1858.
	do	do	Entosphenus epihexodon	Gill.
	Clear Lake	Jordan	Entosphenus tridentatus	Jordan & Gilbert, 1894.
Parrot Ferry	Stanislaus	Rutter & Atkinson	do	

2. Lampetra cibaria (Girard). *Western Brook Lamprey.*

Petromyzon plumbeus Ayres, Proc. Cal. Ac. Nat. Sci. 1854, p. 28, San Francisco.
Ammocœtes cibarius Girard, Pac. Ry. Survey, p. 383, 1859, larva, Puget Sound.
Lampetra cibaria, Jordan & Evermann, Fishes of North and Middle America, pt. I, p. 13, 1896.

Diameter of buccal disk 3.3 in head in front of first gill opening. Supraoral lamina with a tooth at each end, none in middle; middle denticle of lingual tooth enlarged; infraoral lamina crescent shaped with 7 teeth, the 2 outer bicuspid; 3 teeth on each side of mouth, the middle one of each series tricuspid, the others bicuspid; several inicuspid teeth above mouth; diameter of eye 1.5 in distance from eye to first gill opening; head in front of first gill opening 8.5 in body; dorsal fins separated by one-seventh the length of the anterior fin; a broad notch in second dorsal near posterior end; greatest depth equal to length of snout.

LOCAL DISTRIBUTION.

Locality.	Stream.	Basin division.	Collector.	Name as reported.	Authority.
San Francisco	San Francisco Bay	Sacramento	Ayres	Petromyzon plumbeus	Ayres, 1854–1857.
At mouth of Feather River.	Sacramento River	do	Rutter & Chamberlain.	Lampetra cibaria	

3. Pantosteus lahontan Rutter.

Pantosteus lahontan Rutter, Bul. U. S. Fish Comm. for 1902 (March 31, 1903), p. 146, Suisun River (type no. 50587, U.S.N.M.) Coll. Rutter & Chamberlain.

Taken only in the headwaters of North Fork of Feather River—Warner Creek at Johnsons, and North Fork of Feather River at Big Meadows, by Rutter and Chamberlain. Largest specimen 3.7 inches long.

4. Catostomus microps Rutter, new species.

Head 4.5 in length; depth 4.7; eye 6.5 in head (6-inch specimen), 2.2 to 2.3 in interorbital space, which equals snout; dorsal 11; anal 7; scales 17–81 to 87–14, lateral line complete; body heavy; head small, conical; snout blunt; interorbital space rounded, cross section of head being nearly circular; eye small, in middle of head; mouth small, lips thick, 2 rows of papillæ on upper; lower lip deeply incised, 1 row of papillæ across symphysis, 5 cross rows on lobes; cartilaginous sheaths well developed in both jaws; fontanelle almost obsolete in specimens 6 inches long; origin of dorsal in middle of body, its height 1.5 in head, its margin slightly rounded anteriorly; anal reaching rudimentary caudal rays; ventrals about 1.5 in head; pectorals 1.2; caudal 1 to 1.2, deeply emarginate or slightly forked; depth of caudal peduncle 2.7 in head; peritoneum dusky.

Differs from the related species, *occidentalis*, found in the same region and from *snyderi* from the Klamath region in the very small eye, small conical head, and small scales, and in the nearly closed fontanelle. The lips are not notched at the corner, as in *Pantosteus*.

Three specimens from Rush Creek, a small tributary of Ash Creek, near Aden, Modoc County, Cal., collected by Rutter and Chamberlain, September 1, 1898. Type no. 58496, U. S. National Museum. Their measurements, in hundredths of the body length, are given in the following table:

Length of body ....mm..	134	103	89	Insertion anal	0.79	0.78	0.79
Length head	.22	.23	.23	Length dorsal	.15	.15	.15
Depth	.205	.22	.22	Height dorsal	.16	.16	.165
Diameter orbit	.035	.04	.04	Dorsal rays	11	10	11
Interorbital space	.09	.09	.09	Anal rays	7	7	7
Length snout	.105	.10	.10	Scales in lateral line	82	81	81
Depth caudal peduncle	.085	.09	.09	Scales above lateral line	15	16	16
Length caudal peduncle	.17	.16	.16	Scales below lateral line	11	11	11
Insertion dorsal	.49	.51	.51	Scales before dorsal	40	40	41
Insertion ventral	.56	.57	.58				

Fig. 1.—Catostomus microps, new species. Type.

5. **Catostomus tahoensis** Gill & Jordan. *Tahoe Sucker.*

Catostomus tahoensis Gill & Jordan, Bul. U. S. Nat. Mus., XII, p. 173, 1878. Jordan and Evermann, Fishes of North and Mid. Amer., pt. I, p. 177, 1896.

Head 4.4 in length; depth 4.7; eye 5.5 in head, 2.4 in snout, 2.5 in interorbital space, and 1.6 in distance between eye and upper end of gill opening. Interorbital 2.4 in top of head; width of isthmus 4.8 in head, 1.5 in distance between eye and gill opening, 1.6 in width of operculum, and equal to distance between corners of mouth. (Measurements made on a specimen 6.5 inches long.) Dorsal 10 or 11, scales 16–90–14.

Body heavy, profile gradually arched from snout to dorsal; mouth rather small, lips rather large, but somewhat variable in size, covered with coarse tubercles; upper lip with two rows of tubercles and a few scattered ones representing a third outer row; lower lip with one row across symphysis (3 in one specimen with extra large lips), 3 or 4 rounded tubercles and 3 or 4 others coalesced into a continuous ridge in a longitudinal row through lobes; lower lip deeply incised, the margin of lobes hardly reaching vertical through edge of anterior nostril. Orbital rim well developed, leaving a slight groove between it and the middle ridge of interorbital, but the thick skin preventing the groove from showing, the interorbital space being evenly rounded. Origin of dorsal in middle of body, its length about 1.2 in its height. Insertion of ventrals under fourth or fifth ray of dorsal, their length less than height of dorsal. Caudal 1.2 in head, not deeply forked, the middle rays 1.3 in longest. Anal high, reaching well upon caudal, height equal to length of caudal; pectoral a little shorter than caudal. Caudal peduncle compressed, its thickness above end of anal 0.7 its least depth, which is 2.6 in head. Lateral line straight, complete. Peritoneum silvery, thickly dusted with black. Sides often reddish.

Description based on 4 specimens 5 to 6.5 inches long from Warner Creek, a tributary of North Fork of Feather River. The following table gives the variation in the number of scales in the lateral line in specimens from four localities:

Scales.	Warner Creek.	Duck Lake.	Beck-with.	Miller Creek.	Scales.	Warner Creek.	Duck Lake.	Beck-with.	Miller Creek.
	Speci-mens.	*Speci-mens.*	*Speci-mens.*	*Speci-mens.*		*Speci-mens.*	*Speci-mens.*	*Speci-mens.*	*Speci-mens.*
80			1	1	89			2	1
81				1	90				3
82					91			1	1
83				1	92			1	1
84				1	93			1	2
85				1	94			1	
86	1			1	95		1		2
87				2	96	1			
88				2					

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Basin division.	Collector.
Johnsons ranch	Warner Creek	Lahontan	Rutter & Chamberlain.
Big Meadows	North Fork Feather River	do	do.
Do	Duck Lake	do	do.
Beckwith	North Fork Feather River	do	Rutter & Atkinson.
Miller Pass	Miller Creek	do	do.

The specimens from Miller Creek were obtained at its source in Miller Pass, at an elevation of 7,100 feet, with several miles of impassable waterfalls either on the Lake Tahoe or Sacramento side. Trout from Lake Tahoe have been planted in the stream, and it may be that suckers were accidentally introduced at the same time.

6. **Catostomus occidentalis** Ayres. *Western Sucker.*

Catostomus occidentalis Ayres, Daily Placer Times and Transcript, May 30, 1854, San Francisco markets. Agassiz, Amer. Jour. Sci. Arts 1855, p. 94. Jordan & Evermann, Fishes of North & Mid. Amer., pt. I, p. 178, 1896.
Catostomus labiatus Ayres, Proc. Cal. Ac. Sci. 1855, p. 32, Stockton.
Catostomus arcopus Jordan, Bul. U. S. Nat. Mus. 1878, p. 173, South Fork Kern River.

Head 4.1 in body; depth 5; eye 5.5 in head, 2.7 in snout, 2 in interorbital; snout 2 in head. (Measurements on a specimen 218 mm., or 8.5 inches, long, not including caudal fin.)

In general the head is rather slender and somewhat conical. The lips are of moderate size (for the genus), the lobes of the lower extending about to vertical through nostrils; about 7 rows of papillæ on upper lip, those of the middle rows larger; one row of papillæ across symphysis of lower lip and about 9 in a row through lobes. Eye in posterior half of head. Gillrakers few and short. Dorsal outline of body regularly curved, the scales enlarged posteriorly, as is usual with the genus. Dorsal fin inserted about in middle of body, but varying from 0.50 to 0.53 of the body length from tip of snout; rays 12 or 13, sometimes 14; its height greater than base, margin slightly concave. Lateral line straight; pectorals reaching almost to vertical through origin of dorsal; ventrals inserted below middle of body, not quite reaching vent; anal about reaching rudimentary caudal rays, its base about half its height; lobes of caudal about equal, the middle rays about 1.5 in longest; depth of caudal peduncle slightly less than width of interorbital.

The type of this species was secured in the San Francisco markets, and probably came from the lower Sacramento or San Joaquin or their lowland tributaries. Cache Creek is the nearest stream to the probable type locality, from which many specimens have been preserved, and we have based our description on specimens from that stream. They were collected by Mr. Snyder in 1899.

The extremes of measurements, expressed in hundredths of the body, are as follows:

Head	0.22–0.27	Length of caudal peduncle	0.155–0.17
Depth	.18 –.24	Origin of dorsal from snout	.49– .54
Eye	.035–.055	Insertion of ventrals	.56– .58
Interorbital	.085–.11	Origin of anal	.77– .80
Snout	.11 –.13	Base of dorsal	.15– .185
Depth of caudal peduncle	.08 –.095	Height of dorsal	.155– .22

There is little correspondence between the variation of the head and the size of the fish, but frequently the smaller specimens have the larger head. It will also be noticed from the same table that specimens from certain localities have distinctively large or small heads, as the case may be. Thus specimens from Sacramento River at Redding and Middle Fork of Feather River at Nelson Point have heads smaller than the average, while specimens from Wolf Creek, Indian Valley, South Fork Tuolumne River, and St. John Channel of Kaweah River have heads larger than the average. These places are all widely separated, except the Wolf Creek and Nelson Point stations, which are both in the Feather River basin.

The size of the mouth and lips varies greatly. Specimens from North Fork Yuba River at Bullards Bar have the lips enormously developed. Those from North Fork Consumne River and Big Silver Creek are intermediate between the Yuba specimens and those from Wolf Creek, which are larger than the average. Decreasing in size from the latter are specimens from South Fork Tuolumne River, Sacramento River at Redding, Merced River at Benton Mill, and Middle Fork Feather River at Nelson Point. Specimens from Cache Creek and many other stations have lips of about the same size as those from the latter point, which seems to be the typical size for the species. Taking specimens of nearly the same size from the various stations and arranging them in a decreasing series with reference to the size of the lips, we have the following as intermediate between the Nelson Point, or typical specimens, and Olema specimens, which have the smallest lips known to the species: Fresno River; American River at Placerville; Clover Creek, Genesee Valley; Stanislaus River, Parrot Ferry; Middle Fork Feather River, Beckwith; Pitt River, Canby; South Fork Pitt River; Tule River; Feather River, Oroville; Sacramento River, Red Bluff; Sacramento River, Knights Landing; Ash Creek, Aden; and Olema Creek (tributary to Tomales Bay). This series shows that there is no relation between the size of the lips and the portion of the basin, though it may be said that those specimens with the largest lips come from the foothill streams tributary to the lower portion of the Sacramento or San Joaquin River. It is worthy of note that all variations from below the typical to the largest are found in tributaries of Feather River. Olema Creek, where specimens with the smallest lips were found, is not tributary to the Sacramento-San Joaquin basin.

The accompanying outline drawings show the variations in size of lips. The drawings are made from specimens of nearly equal size, and for each specimen the outline has been drawn to a scale corresponding to a body length of 10 inches.

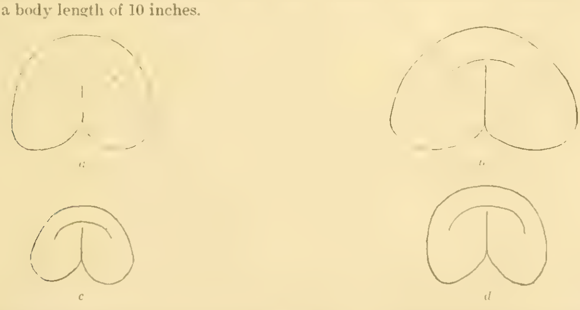


Fig. 2.—Diagram showing size of lips in *Catostomus occidentalis* from (*a*) Wolf Creek, Indian Valley, (*b*) North Fork Yuba River, Bullard's Bar, (*c*) Olema Creek, tributary to Tomales Bay, and (*d*) Middle Fork Feather River, Nelson Point.

The rays of the dorsal vary from 11 to 14. We have counted 393 specimens from 36 localities in the basin. Forty-two specimens have 11 rays in the dorsal, 271 have 12, 86 have 13, and 4 have 14.

The number of scales in the lateral line varies from 60 to 84, 66 to 71 being the prevailing number.

There is no relation between any particular variation and the division of the basin in which the specimens were taken. One or two peculiarities, however, are worth noticing. Beginning with Middle Fork of Feather River at Nelson Point and going south to Big Silver Creek the scales become coarser. The next station, North Fork Consumne River at Pleasant Valley, shows the finest scales in the collection, while the next one after that shows the coarsest.

Taken as a whole, the species is exceedingly variable. Specimens from one locality often have a distinct physiognomy and can, as a whole, be readily distinguished. For example, Pleasant Valley specimens are remarkable for big lips and fine scales, while North Yuba specimens have big lips and coarse scales. The Wolf Creek specimens have large heads, while Sacramento River specimens have small heads, and so on.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Basin division.	Collector.	Name as reported.	Authority.
San Francisco markets.	Sacramento and San Joaquin rivers.	Sacramento	Ayres, Newberry, Cary, Lockington.	Catostomus occidentalis.	Ayres 1854a & 1854–7; Girard 1856; L. Agassiz; Jordan & Jouy; Lockington.
	Sacramento River	do	Ayres	C. labiatus	Ayres 1854–7.
Stockton	San Joaquin River	do			
	Goose Lake	Pitt River	Cope	do	Cope.
	Do	do	Rutter & Chamberlain.	C. occidentalis	
At mouth of Joseph Creek.	North Fork Pitt River.	do	do	do	
Near Alturus	do	do	do	do	
South Fork Post-office	South Fork Pitt River.	do	do	do	
Canby	Pitt River	do	do	do	
Aden	Ash Creek	do	do	do	
Baird	McCloud River	do	Stone; Rutter & Chamberlain.	do	
Redding	Sacramento River	Sacramento	do	do	
Do	Clear Creek	do	do	do	
Anderson	Cottonwood Creek	do	Snyder	Catostomus occidentalis.	MS.
United States hatchery	Battle Creek	do	Rutter & Scofield.	do	
Red Bluff	Sacramento River	do	do	do	
Tehama	Thomas Creek	do	do	do	
Vina	Deer Creek	do	Rutter & Chamberlain.	do	
Chico	Sacramento River	do	do	do	
Jacinto	do	do	do	do	
Wilson's Farm	do	do	do	do	
20 miles below Grimes	do	do	do	do	
	Stoney Creek	do	Snyder	do	MS.
	Cache Creek	do	do	do	MS.
	Clear Lake	do	Jordan & Gilbert.	do	Jordan & Gilbert.
	Putah Creek	do	Snyder	do	MS.
Knights Landing	Sacramento River	do	Rutter & Scofield.	do	
Oroville	Feather River	do	Rutter & Chamberlain.	do	
Crescent Mills	Indian Creek	do	Rutter & Atkinson.	do	
Greenville	Wolf Creek	do	do	do	
Genesee	Clover Creek	do	do	do	
Do	Squaw Queen Creek	do	do	do	
Beckwith	Middle Fork Feather River.	Lahontan	do	do	
Nelson Point	do	Sacramento	do	do	
Bullards Bar	North Fork Yuba River.	do	do	do	
Gerle	Rubicon River	Lahontan	do	do	
Placerville	South Fork American River.	Sacramento	Rutter & Chamberlain.	do	
Near Orelli	Silver Creek	Lahontan	Rutter & Atkinson.	do	
Pleasant Valley	North Fork Consumne River.	Sacramento	do	do	
Parrot Ferry	Stanislaus River	do	do	do	
Baker Ford	Tuolumne River	do	do	do	
Near mouth	South Fork Tuolumne River.	do	do	do	
Benton Mill	Merced River	do	do	do	
Livingstone	do	do	do	do	
Mariposa	Mariposa Creek	do	do	do	
Raymond	Chouchilla River	do	do	do	
Do	Fresno River	do	do	do	
Pollasky	San Joaquin River	do	do	do	
Centerville	Kings River	do	do	do	
Lemon Cove	Kaweah River, St. John Channel.	do	do	do	
Porterville	Tule River	do	do	do	
Bakerfield	Kern River	do	do	do	
	Kern Lake of the Mountains.	do	Gilbert	do	
	South Fork Kern River.	do	Henshaw	Catostomus arenopus.	Jordan 1878; Jordan & Henshaw.

7. **Orthodon microlepidotus** (Ayres). *Greaser Blackfish.*

Leuciscus microlepidotus Ayres, Daily Placer Times and Transcript, 1854, May 30, San Francisco.
Gila microlepidota Ayres, Proc. Cal. Ac. Nat. Sci., vol. I, 1855, p. 21, Sacramento and San Joaquin rivers.
Orthodon microlepidotus, Pac. Ry. Surv., vol. x, 1859, p. 237. Jordan & Evermann, Fishes of North & Mid America, pt. I, p. 207, 1896.

Head 3.8 in body, depth 4; eye 6 in head; interorbital 2.4; snout 3; dorsal 11; anal 9; pectoral 16; ventral 10; scales 27–97–11; teeth 6–6. (Measurements based on a specimen 181 mm. long from Sacramento River at Butte City.)

Body long, slightly compressed; head small, the snout broad, wedge-shaped; mouth small, nearly horizontal, lower jaw included, the maxillary falling far short of eye, 4.5 in head; teeth 6–5 or 6–6; origin of dorsal in middle of body, over insertion of ventrals; ventrals reaching vent. Dusky, nearly black above.

A large minnow of little value, distinguished by the small mouth and fine scales.

The following is a table of measurements of 4 specimens:

Locality.	Sacramento River, Butte City.	Sacramento River, Colusa.	San Joaquin River, Black Diamond.	Kings River, Centerville.
Length of body........mm..	182	140	154	123
Length of head..............	.27	.26	.26	.26
Depth.........................	.25	.25	.25	.25
Diameter orbit..............	.052	.055	.055	.06
Interorbital..................	.115	.11	.11	.11
Length snout................	.09	.08	.08	.08
Depth caudal peduncle.....	.085	.085	.085	.09
Length caudal peduncle....	.21	.22	.21	.20
Scales above lateral line....	26	26	25	24
Scales on lateral line........	103	98	99	95
Scales below lateral line.....	13	13	12	13

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
San Francisco markets......	Sacramento and San Joaquin rivers.	Ayres.................	Leuciscus microlepidotus, Gila microlepidota.	Ayres, 1854a.
Do..........................	....do.........................	Newberry............	Orthodon microlepidotus.	Girard, 1856.
Do..........................	....do.........................	Lockington...........	....do............	Lockington.
	Sacramento River.............	....	....do............	Jordan & Jouy.
	Clear Lake.....................	Jordan................	....do............	Jordan & Gilbert.
Butte City..................	Sacramento River......	Rutter & Scofield...	do........	
Colusa......................	do...............	do.............	do.......	
Arcade......................	Arcade Creek................	Rutter & Atkinson...	....do........	
Ryde.........................	Sacramento River............	Rutter & Chamberlain.	....do.......	
Rio Vista...................	do..............	do..............	do.......	
Black Diamond..............	Suisun Bay........	do..............	do.......	
Centerville..................	China Slough.....	do..............	do.......	
Do..........................	Kings River..................	Rutter & Atkinson...	....do...........	

8. **Lavinia exilicauda** Baird & Girard.

Lavinia exilicauda Baird & Girard, Proc. Ac. Nat. Sci Phila., 1854, p. 137, Sacramento River. Jordan & Evermann, Fishes of North & Mid. Amer., pt. I, p. 209, 1896, and p. 2799, 1898.
Leucosomus occidentalis Baird & Girard, l. c., Poso Creek.
Lavinia compressa Proc. Cal. Ac. Nat. Sci., 1854, p. 21, San Francisco.
Luxilus occidentalis Jordan & Evermann, l. c., p. 247.

Head 4 in body, depth 8.5; eye 3.6 in head; snout 3.6; interorbital 3; dorsal 11, anal 13, scales 13–56–6, teeth 5–5, long and hooked. (Measurements based on a specimen 98 mm. long from Sacramento River at Jacinto.)

In general the head is pyramidal, slightly broader above than below, snout pointed, premaxillary protractile; maxillary slipping under preorbital, without barbel; lower jaw with or without horny sheath; distance between nostrils equal to their distance from tip of snout; eye anterior, large, placed low, a line from tip of snout to tip of opercle passing through middle of pupil (in specimens about 100 mm. long); snout equal to eye; body deep and compressed, regularly tapering to both extremities; caudal peduncle slender, its depth 2.8 in head; lateral line decurved, almost concentric with ventral outline; scales 54 to 62 in lateral line, 12 to 14 above, and 6 or 7 below. Pectorals not reaching ventrals, of 15 or 16 rays; ventrals of 10 rays, inserted under middle of body, extending to vent; dorsal with 11 or 12 rays, rarely 10 or 13, its origin slightly behind insertion of ventrals; anal with 11 to 14 rays, usually 13, margin slightly concave, its origin under end of dorsal; caudal fin large, nearly a half longer than head, deeply cleft, the middle rays 2.2 in longest, lower lobe longer than upper. Color, plain dusky above, pale below, older specimens darker. (Description based on specimens from Jacinto.)

The following tables show the variations in this species:

MEASUREMENTS OF HEAD.

Size.	Number of specimens with head—						
	0.22.	0.22½.	0.23.	0.23½.	0.24.	0.24½.	0.25.
Millimeters.							
58–69					8		5
70–79			3		3		4
80–89		1	5		3	1	1
90–99			1	1	8		2
100–109	1	1			6		
110–119			5		2		1
120–129			2				
130–139		1	1		1		
156		1					

SUMMARY OF THE VARIATIONS IN SIZE OF EYE, SHOWING ITS RELATION TO SIZE OF FISH.

Size.	Number of specimens with eye—				
	0.05½.	0.06.	0.06½.	0.07.	0.07½.
Millimeters.					
58–69		1	2	9	1
70–79		1	2	7	
80–89		5	3	3	
90–99		6	5	1	
100–109	1	4	3		
110–119	5	2		1	
120–129	2				
130–139	1	2			
156	1				

The size of the caudal peduncle as given in the table of measurements varies considerably. The variation in its depth is partly due to the method of preservation and partly to the size of the specimens. There may also be a slight locality variation, specimens from southern localities apparently having the caudal peduncle slightly deeper. Only 7 of the 68 specimens measured have the caudal peduncle over 0.17, and 5 of these are from Tule River. The following table shows that there is some relation between the size of the specimen and the depth of the caudal peduncle, the depth being slightly greater in smaller specimens. The length of the caudal peduncle does not vary with the size of the fish.

MEASUREMENTS OF CAUDAL PEDUNCLE.

Size.	Number of specimens with caudal peduncle having—												
	Depth—						Length—						
	0.07½.	0.08.	0.08½.	0.09.	0.09½.	0.10.	0.14.	0.15.	0.16.	0.17.	0.18.	0.19.	0.20.
Millimeters.													
58-69		2		9		2		1	4	3	4	1	
70-79		1	1	7		1		2	3	3	1		1
80-89		2	1	7		1	2	1	2	6			
90-99		2	3	6		1		1	7	4			
100-109		1	4	3				1	3	4			
110-119		4	2	2					4	4			
120-129		1	1					1		1			
130-139	1	1	1					1	2				
150			1							1			

The extreme variations in other measurements are: Depth, 0.24–0.30; interorbital, 0.07-0.09; snout, 0.06–0.07½; insertion of dorsal, 0.56–0.61.

VARIATION IN SCALES OF THE LATERAL LINE.

Locality.	Number of specimens having scales in lateral line—								
	54.	55.	56.	57.	58.	59.	60.	61.	62.
Battle Creek hatchery								2	
Sacramento River:									
Red Bluff					1	1			2
Chico			1		2				
Jacinto		3	1	2	1	1		1	
20 miles below Grimes					1				
Feather River, Oroville					1		1		
American River, Folsom		1		1					
Antelope Creek, Peryn			2						
Merced River, Livingstone	2		2		1				
China Slough, Centerville	1	4	1	1	1				1
Kings River, Centerville	1	2	1	3	1	1		1	
Kaweah River, St. John Channel	1	3	3	1	2				
Tule River, Porterville	2	1	1						
Total	7	14	12	8	11	3	1	4	3

VARIATION IN FIN RAYS.

Locality.	Number of specimens having—							
	Dorsal—				Anal—			
	10.	11.	12.	13.	11.	12.	13.	14.
Battle Creek hatchery		1	1				2	
Sacramento River:								
Red Bluff		2	2				4	
Chico		1	1	1			3	
Jacinto		7	3				7	2
20 miles below Grimes		1					1	
Feather River, Oroville			2				2	
American River, Folsom			2				1	1
Antelope Creek, Peryn			2				1	1
Sacramento River, Rio Vista		1					1	
San Joaquin River, Black Diamond		1					1	
Merced River, Livingstone			5				5	
China Slough, Centerville		2	8			1	6	3
Kings River, Centerville		2	8		1	2	7	
Kaweah River, St. John Channel		6	4		1	1	7	1
Tule River, Porterville	2	2	1					
Total	2	26	39	1	2	4	48	8

The teeth are usually 5–5, but sometimes 4–5 in specimens from Kings River at Centerville.

The horny sheath of the lower jaw is developed in a few of the specimens from almost every locality. Its presence is a remarkable feature and one that is ordinarily considered of generic value. It is, however, indifferently present or absent in this species and in *Rutilus symmetricus*.

LOCAL DISTRIBUTION.

Locality.	Stream.	Basin division.	Collector.	Name as reported.	Authority.
	Sacramento River	Sacramento	Heermann	Lavinia exilicauda	Girard, 1854 and 1858.
	do	do	Ayres	L. compressa	Ayres, 1854a.
	San Joaquin River	do	Newberry	L. exilicauda	Girard, 1857.
San Franciso market.		do	Lockington	do	Lockington.
	Clear Lake	do	Jordan	do	Jordan & Gilbert.
United States hatchery.	Battle Creek	do	Rutter & Scofield	do	
Red Bluff	Sacramento River	do	do	do	
Chico Bridge	do	do	do	do	
Jacinto	do	do	do	do	
Wilsons Farm	do	do	do	do	
20 miles below Grimes	do	do	do	do	
Mouth of Feather River	do	do	do	do	
Marysville	Feather River	do	Rutter & Chamberlain	do	
Oroville	do	do	do	do	
Grass Valley	Antelope Creek	do	Rutter & Atkinson	do	
Sacramento	Sacramento River	do	Rutter & Scofield	do	
Folsom	American River	do	Rutter & Chamberlain	do	
Rio Vista	Sacramento River	do	do	do	
Collinsville	do	do	do	do	
Black Diamond	Suisun Bay	do	Rutter	do	
Antioch	San Joaquin River	do	Rutter & Chamberlain	do	
Parrot Ferry	Stanislaus	do	Rutter & Atkinson	do	
Livingstone	Merced River	do	do	do	
Raymond	Fresno River	do	do	do	
Pollasky	San Joaquin	do	do	do	
Centerville	China Slough	do	do	do	
Do	Kings River	do	do	do	
St. John Channel	Kaweah River	do	do	do	
Four Creeks	do	do	Heermann	Leucosomus occidentalis.	Girard, 1854, 1858, and 1859.
Porterville	Tule River	do	Rutter & Atkinson	Lavinia exilicauda.	
	Posa Creek	do	Heermann	Leucosomus occidentalis.	Girard, 1854, 1858, and 1859.

9. Mylopharodon conocephalus (Baird & Girard). *Bluefish; Hardhead.*

Gila conocephala Baird & Girard, Proc. Ac. Nat. Sci. Phila. 1854, p. 135, San Joaquin River.
Mylopharodon robustus, Ayres, Proc. Cal. Ac. Nat. Sci. 1855, p. 33, San Francisco.
Mylopharodon conocephalus, Jordan & Evermann, Fishes of North & Mid. Amer., pt. I, p. 219, 1896.

Head 4 in body; depth 4.6; eye 4.5 in head, interorbital 3, snout 3; depth of caudal peduncle 2.8 in head, its length 1.2; dorsal 9; anal 9; pectoral 15; ventral 9; scales 18–74–8; teeth 2, 5–4, 2, the last two of of the first row molar, the others hooked. (Measurements based on a specimen 163 mm. long, from Merced River at Benton Mill.)

The body is heavy, slightly compressed, regularly tapering to the short conical head and the slender caudal peduncle, mouth slightly oblique, terminal, the premaxillary not protractile, the lower jaw slightly shorter than the upper, the maxillary extending almost to vertical through anterior margin of eye; the lateral line slightly decurved; origin of dorsal about in middle of body, high anteriorly, its longest ray 1.4 in head; ventrals inserted slightly in advance of dorsal, their tips reaching anal; caudal broad, deeply forked, the middle rays nearly 2 in longest, the lobes equal.

A large minnow resembling *Ptychocheilus* but readily distinguished by the ridge of skin connecting the premaxillary with the top of the head. The head is also much shorter. This is the most abundant fish in the upper Pitt River and in some of the localities in the foothills.

The following table shows the variation in the number of scales in the lateral line:

Locality.	Number specimens having scales in lateral line—							
	69.	70.	72.	73.	74.	75.	76.	77.
Pitt River			1			1		
Sacramento River					2			
Feather River						1		
Squaw Queen Creek			1	1				
Tuolumne River				1		2	1	1
South Fork Tuolumne River			1					
Merced River						2		
Kings River			1	2				
Kaweah River						1		
Tule River	2	1						
Total	2	1	4	4	2	7	1	1

The number of scales above the lateral line was 18 or 19 in the 22 specimens counted, and 8 or 9 below.

The number of rays in both dorsal and anal fins was invariably 9 in the 22 specimens counted.

Local Distribution.

Locality.	Stream.	Basin division.	Collector.	Name as reported.	Authority.
San Francisco		Sacramento	Newberry	Mylopharodon conocephalus.	Girard, 1856.
Do		do	do	M. robustus	Girard, 1856, 1857.
	Sacramento River	do		M. conocephalus	Jordan & Jouy.
	San Joaquin River	do	Heermann	Gila conocephala	Girard, 1854.
	do	do	Ayers	M. robustus	Ayres, 1854–57.
Alturus	N. Fk. Pitt River	Pitt River	Rutter & Chamberlain.	M. conocephalus	
Canby	Pitt River	do	do	do	
Aden	Ash Creek	do	do	do	
Bieber	Pitt River	do	do	do	
Pittville	do	do	do	do	
Redding	Sacramento River	Sacramento	do	do	
At mouth of Clear Creek.	do	do	do	do	
United States hatchery	Battle Creek	do	Rutter & Scofield	do	
Red Bluff	Sacramento River	do	Rutter	do	
6 miles below Red Bluff	do	do	Rutter & Scofield.	do	
Tehama	do	do	Rutter	do	
Do	Thomas Creek	do	Rutter & Scofield	do	
Chico	Sacramento River	do	do	do	
Jacinto	do	do	do	do	
Grimes	do	do	do	do	
20 miles below Grimes	do	do	do	do	
Mouth of Feather River.	do	do	do	do	
Oroville	Feather River	do	Rutter & Chamberlain.	do	
Crescent Mills	Indian Creek	do	Rutter & Atkinson.	do	
Genesee	Squaw Queen Creek	do	do	do	
Sacramento	Sacramento River	do	do	do	
Folsom	American River	do	Rutter & Chamberlain.	do	
Placerville	S. Fk. American River	do	do	do	
Collinsville	Sacramento River	do	do	do	
Ward Ferry	Tuolumne River	do	Rutter & Atkinson.	do	
Near mouth	S. Fk. Tuolumne River.	do	do	do	
Livingstone	Merced River	do	do	do	
Benton Hill	do	do	do	do	
Raymond	Fresno River	do	do	do	
Pollasky	San Joaquin River	do	do	do	
Centerville	China Slough	do	do	do	
Do	Kings River	do	do	do	
St. John Channel	Kaweah River	do	do	do	
Porterville	Tule River	do	do	do	
Bakerfield	Kern River	do	do	do	

10. Pogonichthys macrolepidotus Ayres. *Split-tail.*

Leuciscus macrolepidotus, Ayers, Daily Placer Times and Transcript, 1854, May 30, San Francisco.
Pogonichthys inæquilobus, Baird & Girard, Proc. Ac. Nat. Sci. Phila. 1854, p. 136, San Joaquin River.
Pogonichthys macrolepidotus, Jordan & Evermann, Fishes North & Mid. Amer., pt. I, p. 223, 1896.

Head 4 in body; depth 4.2; eye 4 in head; interorbital 3; snout 3.2; dorsal 10, anal 9, pectoral 15, ventral 10; scales 11–59–6; teeth 2, 5–5, 2; upper lobe of caudal 2.4 in body. (Measurements based on a specimen 140 mm. long, from Pollasky.)

In general the head is somewhat conical, the eye is rather large and placed anteriorly; the mouth is nearly horizontal, the lower jaw included, the maxillary reaching a vertical between nostril and eye, a small barbel at its tip. The gillrakers are somewhat longer than in other western minnows. Body long, scarcely compressed, but little arched; caudal peduncle deep, half as deep as body; lateral line slightly decurved. Dorsal inserted in middle of body, its anterior rays equal to head and twice as long as posterior rays; anal similar to dorsal, but smaller; ventrals inserted under third ray of dorsal; caudal very large, deeply forked, the upper lobe much longer than the lower and nearly twice as long as the head. Length 12 inches. Readily distinguished by the long upper lobe of caudal fin.

The extremes of measurements are:

Head	0.24–0.27	Depth of caudal peduncle	0.11–0.12
Depth	0.22–0.25	Length of caudal peduncle	0.15–0.18
Eye	0.06–0.075	Upper lobe of caudal fin	0.42–0.45
Interorbital	0.075–0.08	Lower lobe of caudal fin	0.33–0.36
Snout	0.07–0.08		

The following summary of head measurements shows the relations between the size of the head and the length of the fish:

Length of fish.	Number of specimens having head—						
	0.24.	0.245.	0.25.	0.255.	0.26.	0.265.	0.27.
Millimeters.							
70–79						1	1
80–89			3	1	2		
90–99					2		
110–119	1	1	1				
120–129			3				
130–142	1	2	2				

The variation in the size of the eye with reference to the size of the fish is shown in the following:

Length of fish.	Number of specimens having eye—			
	0.06.	0.065.	0.07.	0.075.
Millimeters.				
70–79				2
80–89			4	2
90–99			1	1
110–119	2	1		
120–129	3			
130–142	5			

The difference between the lengths of the caudal lobes varies with the size of the fish, being greater in larger specimens, as shown in the following table:

Length of fish.	Number of specimens having difference between lobes of caudal fin amounting to—			
	0.07.	0.08.	0.09.	0.10.
Millimeters.				
70–79	1			
80–89	1	2	1	
110–119			1	
120–129			2	1
130–142			1	3

The number of rays in the dorsal is uniformly 10 in the 21 specimens examined; 20 have the anal with 9 rays, and one with 8; teeth 2, 5–5, 2 in all specimens examined. The following is a statement of the number of scales in the lateral line:

	Specimens.		Specimens.
56 scales	2	59 scales	3
57 scales	2	60 scales	6
58 scales	7	61 scales	1

There are 11 or 12 scales above the lateral line and 6 or 7 below.

One of the most abundant fishes of the lower rivers and in Suisun Bay. At Battle Creek fishery it feeds on the waste eggs from the spawning platform and from the hatchery. It is also very destructive to salmon eggs on the spawning beds. As many as 50 split-tails may be seen following a spawning salmon. There is no doubt that it also destroys great numbers of salmon alevins.

This species is one of the few minnows that enter brackish water, being very abundant in Suisun Bay, and occasionally taken in San Pablo Bay in nearly pure sea water.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
San Francisco		Ayres	Leuciscus macrolepidotus.	Ayres 1854a.
		Lockington	Pogonichthys inæquilobus.	Lockington.
	Sacramento River	(?)	P. macrolepidotus	Jordan & Jouy.
Redding	do	Rutter & Chamberlain.	do	
Fort Reading	do	Newberry	P. inæquilobus	Girard 1857.
United States hatchery	Battle Creek	Rutter & Scofield	P. macrolepidotus	
Red Bluff	Sacramento River	do	do	
6 miles below Red Bluff	do	do	do	
Tehama	do	do	do	
Chico Bridge	do	do	do	
Jacinto	do	do	do	
Grimes	do	do	do	
Wilson Farm	do	do	do	
20 miles below Grimes	do	do	do	
Knights Landing	do	do	do	
	Clear Lake	Jordan & Gilbert	do	Jordan & Gilbert.
Mouth of Feather River	Sacramento River	Rutter & Scofield	do	
Oroville	Feather River	Rutter & Chamberlain.	do	
Sacramento	Sacramento River	Rutter & Scofield	do	
Folsom	American River	Rutter & Chamberlain.	do	
Ryde	Sacramento River	do	do	
Rio Vista	do	do	do	
Collinsville	do	do	do	
Benicia	Carquinez Straits	do	do	
Black Diamond	Suisun Bay	Rutter	do	
Antioch	San Joaquin River	Rutter & Chamberlain.	do	
Livingstone	Merced River	Rutter & Atkinson	do	
Pollasky	San Joaquin River	do	do	
Fort Miller	do	Heermann	P. inæquilobus	Girard 1854 & 1856.

11. Ptychocheilus grandis (Ayres). *Sacramento Pike.*

Gila gracilis Ayres, Daily Placer Times and Transcript, 1854, May 30, San Francisco.
Gila grandis Ayres, Proc. Cal. Ac. Nat. Sci. 1854, p. 18, San Francisco.
Ptychocheilus major, Agassiz, Am. Jour. Sci. Arts 1855, p. 279, San Francisco.
Ptychocheilus harfordi Jordan & Gilbert, Proc. U. S. Nat. Mus. 1881, p. 72, Sacramento River.
Ptychocheilus oregonensis (Richardson), Jordan & Evermann, Fishes of North & Mid. Amer., pt. I, p. 224, 1896.
Ptychocheilus grandis (Ayres) Jordan & Evermann, op. cit., pt. III, p. 2796, 1898.

Head 3.7 in length; depth 5.5; eye 6.3 in head; interorbital 3.8; snout 2.9; depth of caudal peduncle 3.1 in head; dorsal 9, anal 9, pectoral 15, ventral 10; scales 14–73–7; teeth 2.5–4.2. (Measurements on a specimen 184 mm. long from Pollasky.)

Body long and slender, head long; mouth large, terminal, jaws even, maxillary extending to below anterior margin of eye, no barbel; eye in anterior half of head; scales small, lateral line nearly straight; dorsal inserted behind ventrals, which are behind middle of body; pectorals extending half way to ventrals.

The following are the extremes of measurements:

Head	0.28–0.31	Snout	0.09–0.11
Depth	0.18–0.22	Depth of caudal peduncle	0.085–0.10
Eye	0.05–0.07	Length of caudal peduncle	0.18–0.22
Interorbital	0.07–0.085		

The summary of head measurements indicates the relation between the size of the head and the length of the fish, though there is not enough variation in the size of the specimens to make the table of particular value. In specimens ranging from 80 to 150 mm. the size of the head apparently bears but little relation to the size of the fish.

Length of fish.	Number of specimens having the head—						
	0.28.	0.285.	0.29.	0.295.	0.30.	0.305.	0.31.
Millimeters.							
80–89	1				6		2
90–99	1	3	6		7		2
100–109	4	2	2	2	1	2	
110–119	7	4	7		3		
120–129	2		4		2		
130–139	4				1		
140–149	2						
180–190		1					

Measurements, however, vary inversely with the size of the fish, as is indicated by the following summary table of eye measurements:

Length of fish.	Number of specimens having the eye—				
	0.05.	0.055.	0.06.	0.065.	0.07.
Millimeters.					
80–89				3	4
90–99			8	7	
100–109			14		
110–119		2	20		
120–129		6	4		
130–139		3	1		
140–149		3			
150–159	2				
180–190	1				

The number of scales in the lateral lines of 77 specimens varies from 65 to 78, as follows:

	Specimens.		Specimens.
65 scales	2	72 scales	9
66 scales	3	73 scales	10
67 scales	3	74 scales	8
68 scales	9	75 scales	4
69 scales	5	76 scales	3
70 scales	8	77 scales	2
71 scales	10	78 scales	1

The number of scales in an oblique row backward and downward from the origin of the dorsal to the lateral line is 13 or 14, and from the ventrals to the lateral line 6 or 7. The scales in the type of *Ptychocheilus harfordi* are 15–87–10.

The dorsal fin in one of the 77 specimens has 10 rays, in the others 9. The anal is uniformly of 9 rays.

The teeth of 21 specimens are 2, 5–4, 2; 2 specimens from Pollasky have the teeth 3, 4–4, 2.

LOCAL DISTRIBUTION.

Locality.	Stream.	Collector.	Name as reported.	Authority.
San Francisco	Sacramento and San Joaquin rivers.	Ayres	Gila gracilis	Ayres, 1854a and 1854–7.
Do.		Newberry	G. grandis	
Do.		Cary	Ptychocheilus grandis.	Girard, 1856, 1857, 1858.
Do.		Lockington	P. major	L. Agassiz.
Do.	Sacramento River	Jordan and Gilbert	G. grandis	Lockington.
	do		P. harfordi	Jordan and Gilbert.
	Joseph Creek	Rutter and Chamberlain	P. oregonensis, P. harfordi.	Jordan and Jouy.
Alturus	N. Fk. Pitt River	do	do	
Canby	Pitt River	do	P. grandis	
Aden	Ash Creek	do	do	
Bieber	Pitt River	do	do	
Pittville	do	do	do	
Fall River Mills	Fall River	do	do	
Redding	Sacramento River	do	do	
At mouth of	Clear Creek	do	do	
United States hatchery	Battle Creek	Rutter and Scofield	do	
Red bluff	Sacramento River	do	do	
6 miles below Red Bluff	do	do	do	
Tehama	do	do	do	
At mouth of	Thomas Creek	do	do	
Vina	Sacramento River	do	do	
Chico Bridge	do	do	do	
Jacinto	do	do	do	
Grimes	do	do	do	
Wilson Farm	do	do	do	
20 miles below Grimes	do	do	do	
	Clear Lake	Jordan and Gilbert	P. oregonensis, P. harfordi.	Jordan and Gilbert.
	Allen Springs	Cleveland	P. oregonensis	Eigenmann and Eigenmann.
Knights Landing	Sacramento River	Rutter and Scofield	P. grandis	
At mouth of Feather River.	do	do	do	
Marysville	Feather River	Rutter and Chamberlain	do	
Oroville	do	do	do	
Crescent Mills	Indian Creek	Rutter and Atkinson	do	
Greenville	Wolf Creek	do	do	
Genesee	Squaw Queen Creek	do	do	
Bullards Bar	N. Fk. Yuba River	do	do	
Sacramento	Sacramento River	do	do	
Placerville	American River	Rutter and Chamberlain.	do	
Walnut Grove	Sacramento River	Rutter	do	
Rio Vista	do	Rutter and Chamberlain.	do	
Benicia	Carquinez Straits	do	do	
Antioch	San Joaquin River.	do	do	
Modesto	Tuolumne River	Rutter and Atkinson.	do	
At mouth of	S. Fk. Tuolumne River	do	do	
Parrot Ferry	Stanislaus River	do	do	
Livingstone	Merced River.	do	do	
Benton Mill	do	do	do	
Raymond	Chouchilla River.	do	do	
Do.	Fresno River	do	do	
Pollasky	San Joaquin River.	do	do	
Centerville	China Slough	do	do	
Do	Kings River	do	do	
St. John Channel	Kaweah River	do	do	
Porterville	Tule River	do	do	
Bakersfield	Kern River	do	do	

12. Leuciscus crassicauda (Baird & Girard). *Sacramento Chub.*

Leuciscus gibbosus Ayres, Daily Placer Times and Transcript, May 30, 1854, San Francisco.
Lavinia crassicauda Baird & Girard, Proc. Ac. Nat. Sci. Phila., 1854, p. 137, San Joaquin River.
Lavinia gibbosa Ayres, Proc. Cal. Ac. Nat. Sci. 1854, p. 20, San Francisco markets.
Tigoma crassa Girard, Proc. Ac. Nat. Sci. Phila., 1856, p. 207, Sacramento River.
Siboma crassicauda Girard, op. cit., p. 208.
Squalius gibbosus, Jordan & Gilbert, Synopsis Fishes of North Amer., p. 239, 1882.
Squalius crassus Jordan & Gilbert, op. cit., p. 241.
Leuciscus crassicauda, Jordan & Evermann, Fishes N. & Mid. Amer., pt. I, p. 231, 1896.

Of this species we have two specimens, 4 and 9 inches long. The measurements of the larger are:

Head 3.8 in body, depth 3.7; eye 6 in head, snout 3.1; teeth 2, 5–4, 2; dorsal 9, anal 9; scales 12–54–6. For the smaller specimen: Head 3.6 in body, depth 3.9; eye 4.6 in head, snout 3.2; teeth 2, 5–4, 1; dorsal 8, anal 9, scales 10–53–6.

Head conical, profile straight, snout acuminate, mouth oblique, jaws even, maxillary extending to vertical through nostrils, slipping under preorbital. Body elongate, somewhat compressed, the dorsal outline strongly arched at occiput in larger specimen (regularly arched from snout to dorsal in smaller specimen); caudal peduncle very deep and compressed, 1.9 in head, not at all expanding at base of caudal; origin of dorsal midway between tip of snout and tip of middle caudal rays, ventrals inserted under or slightly in advance of origin of dorsal, origin of anal entirely behind dorsal; margin of dorsal and anal convex; caudal fin shorter than head, forked, middle rays 1.6 in longest, lobes equal; lateral line nearly straight. Dusky above, changing to silvery below. Young with a black spot at base of caudal.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
San Francisco		Hammond	Lavinia crassicauda	Girard, 1854.
Do		Ayres	L. gibbosa	Ayres, 1854, 1854–7.
Do		Lockington	Siboma crassicauda	Lockington.
	Sacramento River		Squalius gibbosus	Jordan and Jouy.
Fort Reading	do	Newberry	Tigoma crassa	Girard, 1856, 1857, 1858.
Mouth of Feather River	do	Rutter & Scofield	Leuciscus crassicauda	
	Clear Lake	Jordan & Gilbert	do	Jordan & Gilbert.
	San Joaquin River	Heermann	Siboma crassicauda	Girard, 1856.
	Merced River	do	do	Do.
St. John Channel	Kaweah River	Rutter & Atkinson	Leuciscus crassicauda	

There is some doubt as to the validity of the nominal species *Leuciscus conformis*. Girard's notes and descriptions are entirely conflicting, and his type is the only specimen ever reported. His comparative statement of the differences between *crassicauda* and *conformis* is just the opposite of the differences found in his descriptions of the two species.

The two nominal species are represented in our collection by four specimens, two of which are *crassicauda*, as noted above. The other two are different, apparently, and we place them provisionally under the name *Leuciscus conformis* (Baird & Girard).

13. Leuciscus conformis (Baird & Girard).

Lavinia conformis Baird & Girard, Proc. Ac. Nat. Sci. Phila. 1854, p. 137, Poso Creek, Tulare Valley.
Tigoma conformis Girard, Pacific Ry. Survey, vol. x, p. 289, 1858.
Leuciscus conformis Jordan & Evermann, Fishes North & Mid. Amer., pt. I, p. 231, 1896.

Of this species we also have two specimens, one 7 inches long, the other 3.5. The measurements of the larger specimen are:

Head 4 in body; depth 3.5; eye 4.5 in head; snout 3.6; dorsal 10, anal 11, scales 12–57–7. The smaller specimen has the eye 4 in head, dorsal 11; anal 11; scales 12–60–5; teeth 1, 5–5, 1.

The head is conical, the profile slightly convex, the snout rather pointed; the mouth is oblique, the lower jaw included; the maxillary extends to vertical through middle of nostril, slipping under preorbital. The body is rather deep, compressed, regularly tapering to both extremities; the caudal peduncle is deep, 2.2 in head, expanded at base of caudal as usual in minnows. The origin of the dorsal is midway between tip of snout and middle of middle caudal rays; ventrals inserted slightly in

advance of dorsal; origin of anal under posterior ray of dorsal; margin of dorsal and anal straight; caudal fin longer than head, forked, the middle ray 1.6 in longest, upper lobe longer than lower. Lateral line decurved anteriorly, scales heavily scored. Young with a black spot at base of caudal.

The specimens here described as *conformis* differ from *crassicauda* in having the caudal peduncle less deep, the caudal fin longer than head and its upper lobe longer than the lower, longer dorsal and anal fins, finer scales, even jaws, and heavier striation on scales. Some of these distinctions are just the opposite of those given by Girard. The following are his distinctions: "The general appearance of the fish [*Tigoma conformis*] is suggestive of *Lavinia crassicauda;* the body is deeper and proportionately less elongated, the eye much smaller, and the scales larger." In his descriptions, however, he says, of *Tigoma conformis*, "Eye moderate sized; its diameter entering nearly five times in the length of the side of the head," and of *Siboma crassicauda*, "Eye rather small, subcircular, its diameter entering nearly six times in the length of the side of the head." His comparison of the eye does not agree with his descriptions, and there may be a similar discrepancy with regard to the other characters.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
20 miles below Grimes	Sacramento River	Rutter & Scofield	Leuciscus conformis.	
St. John Channel	Kaweah River	Rutter & Atkinson	do	
Tulare Valley	Posa Creek	Heermann	Lavinia conformis. Tigoma conformis.	Girard 1854, 1856, 1858.

14. Leuciscus egregius (Girard).

Tigoma egregia Girard, Pac. Ry. Surv., vol. x, p. 291, 1859, locality unknown.
Phoxinus clevelandi Eigenmann & Eigenmann, West Am. Scientist, 1889, p. 149, Ætna Springs, Napa County.
Leuciscus egregius Jordan & Evermann, Fishes North & Mid. Amer., pt. I, p. 237, 1896.

A small minnow with red sides, common in Nevada streams, but found on both sides of the Sierras in streams draining Lassen Butte. The following is a tabular statement of fin and scale counts of specimens from Warner Creek:

Counts.	No. of specimens.	Counts.	No. of specimens.
Dorsal:		Scales—Continued.	
8 rays	8	Along lateral line—	
9 rays	2	54 scales	1
Anal:		55 scales	5
8 rays	4	57 scales	2
9 rays	6	58 scales	1
Scales:		61 scales	1
Above lateral line—		Below lateral line—	
12 scales	1	7 scales	4
13 scales	3	8 scales	4
14 scales	6	9 scales	2

LOCAL DISTRIBUTION.

Locality.	Stream.	Basin division.	Collector.	Name as reported.	Authority.
Johnson Ranch	Warner Creek	Lahontan	Rutter & Chamberlain	Leuciscus egregius.	
	Ætna Springs	Sacramento	Cleveland	Phoxinus clevelandi.	Eigenmann & Eigenmann.

15. Rutilus bicolor (Girard). *Klamath Lake Roach.*

Algansea bicolor Girard, Proc. Ac. Nat. Sci. Phila. 1856, p. 183, Klamath Lake.
Myloleucus parovanus Cope, Proc. Ac. Nat. Sci. Phila. 1883, p. 143, Goose Lake.
Myloleucus thalassinus Cope, Proc. Ac. Nat. Sci. Phila. 1883, p. 143, Goose Lake.
Rutilus bicolor Jordan & Evermann, Fishes North & Mid. Amer., pt. I, p. 244, 1896.

Head 3.6 in body, depth 3.3; eye 5.6 in head, interorbital 3.1, snout 3.5, depth of caudal peduncle 2.2; dorsal 9; anal 8; scales 11–49–6; teeth 5–4. [Specimen 126 mm. long.]

Head conical, its depth at occiput about 1.6 in its length; mouth oblique, jaws even, or lower included. Top of premaxillary on level with lower edge of pupil; shortest distance across preorbital about .8 of eye. Tip of lower jaw rounded, not truncated or trenchant as in *symmetricus*. Caudal peduncle deep and compressed, but little tapering, its depth equal to snout and eye in larger specimens. Teeth 5–4, sometimes 4–4.

Description based on specimens 55 to 158 mm. long from South Fork Pitt River.

The following table indicates the variation in scale and ray counts and number of teeth:

Locality.	Specimens having— Lateral line— 44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	Dorsal rays— 8.	9.	10.	Anal rays— 7.	8.	9.	Teeth 5–4.	Teeth 4–4.
Goose Lake	...	4		1	1															6			[illegible]	1	3	1
South Fork Pitt River					[illegible]	1	1													10			[illegible]	1	5	..
Pitt River, Canby						1		[illegible]		1				1						4	1			2	5	..
Ash Creek, Aden	[illegible]	1		2	1			2		2										11	1		1		8	1
Pitt River, Bieber								1													1				..	1
Fall River						1	2	1			1									1	1		[illegible]	2	3	
Hat Creek, Cassel	...	...	...	...	...	...	...	...	1	...	...	2	1	2	2	1	...	1	3	7	....	1	9	....	5	5
Wolf Creek, Greenville	...	...	1	6	3	3	3	3	1	2	...	...	...	...	...	...	...	...	7	16	....	2	20	1	1	....
Total	1	5	1	9	7	9	11	9	3	5	1	2	1	3	2	1	...	1	11	58	4	3	60	10	30	8

The head varies from 0.26½ to 0.32, being longest in specimens from Goose Lake, which vary from 0.29 to 0.32. The average size in other localities is about 0.28.

The depth varies from 0.25½ to 0.31, being least in the specimens from Wolf Creek, a tributary of Indian Creek, near Greenville, Plumas County. Goose Lake specimens have the depth slightly greater, while the deepest specimens come from South Fork Pitt River.

The eye and interorbital vary inversely with the size of the fish. The snout varies but little, and the depth of the caudal peduncle only from 0.115 to 0.13. The other measurements show considerable variation, but the variations are not characteristic of localities.

The scales range from 44 to 61, averaging about 49 or 50, being somewhat more numerous in specimens from Hat Creek. The number of scales above the lateral line is usually 11 or 12, sometimes 13; the number below is 6 or 7.

The dorsal rays are 8, 9, or 10, and the anal 7, 8, or 9, without reference to locality. The teeth are usually 5–4, but occasionally 4–4. Half of the specimens examined from Hat Creek have the teeth 4–4.

The greatest variation is in the head. Its shape is even more variable than its length, the South Fork Pitt River and Goose Lake specimens exhibiting the two extremes. The former has a short triangular head (when viewed from the side), the profile steep, the mouth oblique, but much less so than in the Goose Lake specimens, the mandibles not forming a distinct angle with the lower outline, and the nape swollen. The Goose Lake specimens have the head long and slender, appearing quadrangular when viewed from the side, the profile more nearly horizontal, the mouth very oblique, the lower jaw forming a distinct angle with the lower outline, and the nape not swollen. All possible intergradations are found in other localities, and a full series of intergradations are known from Klamath Lake.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
Oregon	Goose Lake	Cope	Myloleucus parovanus; M. thalassinus	Cope.
California	do	Rutter & Chamberlain	Rutilus bicolor	
South Fork Post-office	South Fork Pitt River	do	do	
Canby	Pitt River	do	do	
Aden	Ash Creek	do	do	
Pittville	Pitt River	do	do	
Dana	Fall River	do	do	
Cassel	Hat Creek	do	do	
Greenville, Indian Valley	Wolf Creek	Rutter & Atkinson	do	

16. Rutilus symmetricus (Baird & Girard). *California Roach.*

Pogonichthys symmetricus Baird & Girard, Proc. Ac. Nat. Sci. Phila., 1854, p. 136, San Joaquin River, Fort Miller.
Algonsea formosa Girard, Proc. Ac. Nat. Sci. Phila., 1856, p. 183, Merced and Mojave rivers.
Leucos formosus Jordan & Henshaw, Wheeler Survey, p. 193, 1878.
Rutilus symmetricus Jordan & Evermann, Fishes North & Mid. Amer., pt. 1, 245, 1896.

Head 4.1 in body; depth 4.4; eye 3.6 in head; interorbital and snout equal, 3 in head; depth of head at occiput 1.5 in its length. Teeth 5–4, long and hooked, the 5 being on the left side; scales 12–51–7, dorsal 10, anal 9. (Measurements on a specimen 86 mm. long from San Joaquin River at Pollasky.)

In general the head is small and conical, 0.25 to 0.27 of body; depth of body 0.23 to 0.25 of its length; mouth small, lateral cleft slightly oblique, anterior cleft horizontal (not arched), lower jaw included, more or less trenchant, and its tip often covered with a horny sheath; eye rather large, its diameter 0.06 to 0.07 of body, almost wholly in anterior half of head; snout broad and blunt, nostrils farther from each other than from tip of snout; the lower jaw with a horny or cartilaginous sheath. Ventrals inserted in middle of body, reaching to vent; dorsal of 10 rays, its origin slightly behind ventrals, 0.58 to 0.60 of body length from tip of snout, its longest ray 1.2 in head; anal inserted under last ray of dorsal, of 9 or sometimes 8 rays; caudal very large, its length one-third that of body, widely spread, with 10 rudimentary rays, deeply forked, the middle rays 2.3 in longest, upper lobe slightly longer than lower. Scales 12–18 to 51–7 or 8. Color, dusky above, gradually changing to silvery on belly, cheeks silvery, the fins nearly colorless, but the rudimentary caudal rays quite dusky. A dark stripe along middle of side is sometimes faintly separated from the dusky color of the back. (Description is based on several specimens, the largest 5 inches long, from San Joaquin River at Pollasky, about 2 miles from Fort Miller, the type locality.)

The head varies from 0.24 of the body in specimens 67 mm. long from North Fork Consumne River at Pleasant Valley, and another 85 mm. long from Thomas Creek to 0.28 in a specimen 46 mm. long from North Fork of Pitt River. The size of the head in the 96 specimens measured may be stated in tabular form as follows:

Size of head:	Specimens.	Size of head:	Specimens.
0.24	2	0.265	13
0.245	1	0.27	21
0.25	24	0.275	1
0.255	3	0.28	1
0.26	30		

The typical form has the head 0.27 or 0.26. Such are found in San Joaquin River at Pollasky (type locality); also in Kings, St. John or Kaweah, Tule, Chouchilla, and North Fork Merced rivers, and in Merced River at Benton Mill and Livingston. Specimens from Battle Creek, Stanislaus River, and Mariposa Creek have the head 0.26 or 0.25, and specimens from Thomas Creek and North Fork Consumne River have the head 0.25 or 0.24; but the size of the head does not correspond with other variations. The Thomas Creek and Consumne River specimens do not at all resemble each other, while the Mariposa specimens and those from North Fork Merced River do look much alike.

The eye usually measures 0.07, but is often much smaller. In specimens from Battle Creek it is 0.07 or 0.065; from Thomas Creek 0.065 or 0.06; North Fork Merced River 0.06, rarely 0.065 or 0.055; Mariposa Creek 0.055, rarely 0.06 or 0.05. The greatest variation in one locality is that of Merced River, at Benton Mill, from 0.055 to 0.07. The tip of the lower jaw is scarcely rounded and not arched. It is often more or less trenchant, and is frequently tipped with a sheath that is sometimes cartilaginous and sometimes horny. The bony sheath is deciduous in preserved specimens, which accounts for its apparent absence in some instances. It resembles that of *Acrocheilus*, but the cutting edge is thinner. It is present in all the specimens from North Fork Consumne River and in half those from North Fork Merced and from San Joaquin at Pollasky. Only a few of the specimens from the Stanislaus River, Merced at Livingston, Chouchilla River, and Mariposa Creek have the horny sheath; and it is entirely wanting in specimens from Battle Creek, Thomas Creek, and Merced River at Benton Mill. The teeth are 5–4, but sometimes 4–4. The scales of the lateral line vary from 47 to 56, the greatest variation, 48 to 56, being found in specimens from Mariposa Creek. The number above the lateral line is usually 12 or 13, but varies from 11 to 15; below lateral line 6 or 7, sometimes 8.

The following table indicates the variation in scale and ray counts, giving the number of specimens in which the various counts were made:

Locality.	Number of specimens having—															
	Scales—										Dorsal rays—			Anal rays—		
	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	8.	9.	10.	7.	8.	9.
San Joaquin River, Pollasky	....	1	....	2	3	..	....	....	....	....	....	....	6	....	1	5
Kings River, Centerville	2	....	1	2	....	....	....	....	....	....	....	2	3	....	....	5
Kaweah River, St. John Channel	1	1	3	4	....	1	....	....	....	....	....	2	8	....	3	7
Tule River, Porterville	3	2	3	2	....	....	....	....	....	....	....	8	2	....	8	2
Chouchilla River near Raymond	1	5	4	....	....	....	....	....	....	....	....	9	1	....	10	....
Merced River, Livingstone	1	....	....	....	1	....	....	....	....	....	....	....	2	....	....	2
Merced River, Benton Mill	....	....	1	4	1	2	....	....	....	....	....	1	7	....	1	7
Stanislaus River, Parrot Ferry	....	....	....	1	1	3	1	3	1	....	....	1	9	....	1	9
North Fork Merced River	....	....	....	....	....	3	3	4	....	....	....	10	....	....	10	....
Mariposa Creek	....	1	....	1	1	2	2	2	....	1	1	9	....	....	10	....
North Fork Consumne River, Pleasant Valley	....	....	....	1	....	1	....	....	....	2	....	1	3	....	....	4
North Fork Pitt River	....	....	....	....	....	1	....	....	....	....	1	....	....	1	....	....
Total	8	10	12	17	7	13	6	9	1	3	2	43	41	1	44	41

The insertion of the dorsal varies from 0.57 to 0.61 of the body length from the tip of the snout.

The dorsal rays are 10 or 9, one specimen from Mariposa Creek having but 8. Anal 8 or 9. Usually nearly all specimens from one locality have the same number. In these numbers the last double ray is counted as two when both divisions are divided.

The caudal peduncle is characteristically slender in *symmetricus*. Typically its depth is 0.09 or 0.10, which is the size in specimens from San Joaquin at Pollasky, Kings River, and St. John or Kaweah River. It is 0.10 in specimens from Thomas Creek, Stanislaus River, and Merced River at Livingston and Benton Mill; 0.10 or 0.11 from Battle Creek, North Fork Merced, Mariposa Creek, Chouchilla and Tule River; and 0.11 or 0.12 from North Fork Consumne River and North Fork Pitt River.

The size of the caudal fin varies much. Usually it is about one-third as long as the body, but in specimens from Mariposa Creek, North Fork Merced River, North Fork Consumne River, and North Fork Pitt River it is only one-fourth as long as the body. From other localities all possible intergradations may be obtained. Those specimens with the longest fin have it the most deeply forked.

The variations noted fall into three groups, though hardly of such a nature as to permit of even subspecific distinction.

First is the Mariposa form, which differs from the Pollasky or typical form in having a smaller head, smaller eye, smaller fins, especially the caudal, one ray fewer in dorsal and anal, deeper caudal peduncle, and greater variation in the number of scales, 48 to 56. Specimens from North Fork Merced River at Bower Cave are very similar, but have a slightly larger eye, and the head is of typical size. The specimens of the 2 localities have independently developed similar variations, as there is no direct connection between the two streams. Mariposa Creek is a mere brook, emptying into the dry bed of Mariposa River. Its water reaches the San Joaquin River only after heavy winter rains. Mariposa Creek is south of Merced River, so that it and North Fork Merced do not even drain opposite slopes of the same watershed. There is a fall in the latter stream below Bower Cave, which prevents the ascent of fishes from the main river, *Rutilus* and *Salmo* being the only fishes in the North Fork above the fall.

The second variation is the Pleasant Valley form. So far as measurements go this form runs close to the Mariposa form, but its general appearance is quite different. The head is slender, not conical, the depth at occiput less than in any other form, the snout very blunt. These characters show in a less degree in specimens from Tule River and Battle Creek. The caudal peduncle is deep, the caudal fin intermediate in size between that of Mariposa and Pollasky forms. The horny sheath is well developed in all specimens, the teeth 5–4 in three specimens, 4–4 in one; the lateral stripe very distinct. Represented by 4 specimens from North Fork Consumne River near Pleasant Valley. The stream is dry in its lower course during the summer.

The third or Alturus form has a long slender body, head and eye of typical size, caudal peduncle as deep as in the Pleasant Valley form, lower jaw not so much included as in other forms, and scales

more imbricated. We have but a few small specimens of this form, the longest being but 3 inches long. They were taken in North Fork of Pitt River near Alturus and at mouth of Joseph Creek, several hundred miles from where any other specimens of *symmetricus* have been taken. The form may prove not to be *symmetricus*, but we can not identify it otherwise with the material at hand.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
At mouth of Joseph Creek	North Fork Pitt River	Rutter & Chamberlain.	Rutilus symmetricus.	
Near Alturus	do	do	do	
Redding	Sacramento River	do	do	
At mouth of	Clear Creek	do	do	
United States hatchery	Battle Creek	do	do	
At mouth of	Thomas Creek	Rutter & Scofield	do	
Pleasant Valley	North Fork Consumne River.	Rutter & Atkinson.	do	
Baker Ford	Tuolumne River	do	do	
Near mouth of	South Fork Tuolumne River.	do	do	
Parrot Ferry	Stanislaus River	do	do	
Bower Cave	North Fork Merced River	do	do	
Benton Mill	Merced River	do	do	
Livingston	do	do	do	
	do	Heermann	Algonsea formosa	Girard, 1856.
Mariposa	Mariposa Creek	Rutter & Atkinson.	Rutilus symmetricus.	
Raymond	Chowchilla River	do	do	
Pollasky	San Joaquin River	do	do	
Fort Miller	do	Heermann	Pogonichthys symmetricus.	Girard, 1854.
Centerville	Kings River	Rutter & Atkinson.	Rutilus symmetricus.	
St. John Channel	Kaweah River	do	do	
Porterville	Tule River	do	do	
	Kern Lake	Henshaw	Leucos formosus	Jordan & Henshaw.

17. Agosia robusta Rutter.

Agosia robusta Rutter, Bul. U. S. Fish Comm., vol. XXII, collection 1902, p. 148, fig., Prosser Creek, Cal.

Body heavy, highest at shoulder, ventral outline curved almost as much as dorsal; head large, 3.75 to 4 in length; snout blunt, but little overlapping, and never projecting beyond the premaxillary; mouth oblique, barbels usually absent, present on 10 to 50 per cent of the specimens from any one locality; pectoral about equal to head behind nostril, variable; caudal moderately forked, length of middle rays two-thirds of outer; lateral line nearly always incomplete; scales 49 to 77, usually varying about 12 in one locality; usually 2 lateral stripes, the upper extending from snout to caudal, the lower branching off from the upper behind the head and ending along base of anal; cheeks abruptly silvery below lateral stripe.

This species differs from *nubila* in the heavy body, blunt rounded snout, incomplete lateral line, and in the absence of scattered brown scales. It differs from *carringtoni* also in the heavy body and incomplete lateral line, and in the shorter pectorals, the anterior rays of anal scarcely or not at all extending beyond posterior when fin is depressed, a greater development of rudimentary caudal rays which usually form short keels along caudal peduncle, and in the silvery stripe across cheeks.

In the main Sacramento River and the lower portion of its tributaries there appears to be a more slender form, but our material is too meager for accurate determinations. The only adults are from Sacramento River at Sims. They have a small head, 4.33 in body, the lateral line is complete, the scales 69 to 77; the mouth is inferior, the snout projecting, and the maxillaries with barbels; the eye is 4.5 in the head. Specimen 3.4 inches long. Young specimens similar to the young taken at Sims were secured in Battle Creek at the government fishery station, and in American River at Placerville. The Kings River specimens are more like the type of *robusta*.

The following table gives the variation in scales of lateral line and in rays of the dorsal and anal fin:

Locality.	Number of specimens having— Scales— 49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.	64.	65.	66.
Goose Lake														2	1			
Joseph Creek													1	2		1	1	1
South Fork Pitt River																		
Rush Creek																		3
Fall River							1		1	3	1			1	3		3	
Burney Creek	2	3	4	1	1	2	1	1		1	2	1						
North Fork Feather, Coppervale											4	2		3	2		2	2
Duck Lake											2					3	1	1
Clover Valley									1		1				1	3	1	2
Spanish Creek, Quincy											1	2	1	2		1		2
Middle Fork Feather, Beckwith										1	1		1			3	1	1
Kings River, Centerville											1						1	
Total	2	3	4	1	1	2	2	1	2	5	13	5	3	10	7	11	10	12

Locality.	Number of specimens having— Scales— 67.	68.	69.	70.	71.	72.	73.	74.	75.	76.	77.	Dorsal— 7.	8.	9.	Anal— 6.	7.	8.
Goose Lake				1						1			5			5	
Joseph Creek	3	3	4	1	2	1						1	18	1	5	15	
South Fork Pitt River			1											1			1
Rush Creek	2	2		2		2	1	2	1	2	1		15	3		18	
Fall River		1			2								16			16	
Burney Creek												4	14	2	2	18	
North Fork Feather, Coppervale	3	1		1								2	17	1		19	1
Duck Lake	1	2	4	2	1		2			1			20			20	
Clover Valley	3	2	1		1	2	2					1	19			20	
Spanish Creek, Quincy	1												8	2		9	1
Middle Fork Feather, Beckwith		1			1								9	1		10	
Kings River, Centerville													1	1		2	
Total	13	12	10	7	7	5	5	2	1	4	1	8	142	12	7	152	3

The species is quite variable. The head varies from 3.6 to 4.3 in the body. The pectoral may be almost as long as the head, or only equal head behind pupil. The Burney Creek specimens have the shortest pectorals as well as the coarsest scales, the pectorals being equal to head behind some point in pupil. The margin of the anal fin may be straight, convex, or S-shaped with the convex portion anterior; the anterior rays usually do not overlap the posterior when the fin is depressed, though the reverse is sometimes true.

Local Distribution.

Locality.	Stream or lake.	Collector.
	Goose Lake	Rutter & Chamberlain.
Davis Creek Post-office	Davis Creek	do.
	Joseph Creek	do.
Alturus	North Fork Pitt River	do.
South Fork Post-office	South Fork Pitt River	do.
Canby	Pitt River	do.
Aden	Ash Creek	do.
Dana	Fall River	do.
Fall River Mills	do	do.
Burneyville	Burney Creek	do.
Sims	Sacramento River	do.
United States hatchery	Battle Creek	do.
Oroville	Feather River	do.
Johnsons	Warner Creek	do.
	Duck Lake	do.
Big Meadows	North Fork Feather River	do.
Quincy	Spanish Creek	Rutter & Atkinson.
Crescent Mills	Indian Creek	do
Greenville	Wolf Creek	do
Clover Valley	Clover Creek	do
Beckwith	Middle Fork Feather River	do.
Placerville	American River	Rutter & Chamberlain.
Centerville	Kings River	Rutter & Atkinson.

18. Salmo irideus Gibbons. *Rainbow Trout.*

Salmo iridea Gibbons, Proc. Cal. Ac. Nat. Sci. 1856, p. 36, San Leandro Creek, San Francisco Bay. Jordan & Evermann, Fishes North & Mid. Amer., pt. I, p. 500, 1896.
Salmo rivularius Ayres, Proc. Cal. Ac. Nat. Sci. 1856, p. 43, Martinez Creek.
Salar iridea Girard, Pac. Ry. Surv., vol. VI, p. 33, 1857, Chico Creek.
Salmo tsuppitch Jordan & Henshaw, Wheeler Survey, p. 196, 1878, Kern River and tributary of Pitt River.
Salmo henshawi Jordan, Wheeler Survey, p. 197, 1878, McCloud River.
Salmo pleuriticus Jordan & Henshaw, op. cit., p. 198, South Fork Kern River.
Salmo mykiss irideus Jordan & Gilbert, Bul. U. S. Fish Comm., vol. XIV, 1894, p. 139, Clear Lake.
Salmo irideus stonei Jordan, Thirteenth Biennial Report Cal. Fish Comm. 1894, p. 142, McCloud River. Jordan & Evermann, op. cit., p. 503.
Salmo gairdneri shasta Jordan, op. cit., p. 142, same place. Jordan & Evermann, op. cit., p. 502.
Salmo gairdneri gilberti Jordan, op. cit., p. 143, Kern River. Jordan & Evermann, op. cit., p. 502.

The most widely distributed species found in the basin. Exceedingly variable. Found in many isolated localities, in some of which it has developed into forms more or less peculiar. The following variations are worthy of note:

The common form, found throughout the basin, has the back dusky olive, lower sides and belly silvery; back and sides to below lateral line, and dorsal and caudal fins, thickly covered with small black spots; a broad, ill-defined, purplish stripe from side of head to base of caudal fin; tips of dorsal, anal, and ventrals often white.

The trout from upper McCloud River are dusky above, pale below, a reddish-brown stripe along sides, opercles washed with same; back and sides, dorsal and caudal fins thickly covered with oval or round black spots about half size of pupil; belly and lower fins yellowish; tips of dorsal, anal, and ventrals white. Very abundant. About six inches long; scales small, 146 to 165.

The form found in South Fork Battle Creek above the falls closely resembles that found in the upper McCloud River. Both forms have finer scales than the average, and those from Battle Creek have the finest scales recorded from any locality. The following is a detailed description of the Battle Creek specimens:

Head 3.7 to 4 in length, depth 4 to 4.7; eye 3.5 to 4 in head, snout 4.5 to 5; maxillary 2 to 2.2 in head, extending to below posterior margin of eye (specimens 4.5 to 5.8 inches long). Dorsal 11 or 12; anal 10 or 11; branchiostegals 10 to 12; gillrakers 5 to 7+10 to 12. Origin of dorsal in middle of body, ventrals inserted under fifth ray of dorsal. Height of dorsal 1.7 in head, anal 2.7. Scales small, not overlapping, pores in lateral line 114 to 123, cross series of scales 151 to 176, scales before dorsal 66 to 84, above lateral line 28 to 32, below lateral line 25 to 31. Margin of anal S-shaped, the anterior portion convex and longer, the longest rays overlapping shortest by 0.7 the length of the latter. Color brownish olive, very faint purplish on sides; very few spots, more numerous on dorsal and adipose fin, few or none on caudal; lower fins colorless, parr marks present even in largest specimens.

Description based on 11 specimens 4.5 to 5.8 inches long.

The trout of North Fork Feather River near source, locally known as West Fork, are of two forms with regard to color. One has very fine black specks thickly scattered over back, dorsal, and caudal fins; the other has much larger spots, about the size of pupil. Some specimens have a reddish tinge on dentaries, but this is irrespective of other coloration. These variations have been noticed in other places, but never so strongly marked as in this locality.

The Goose Lake trout has the body entirely silvery, with black spots very small and widely separated, not occurring as low as the lateral line. In the few specimens secured the maxillary is longer than it is in specimens from other localities; the base of the dorsal fin is shorter, 2.2 in head (1.7 in specimens from other localities); dorsal rays 10.

The trout in a series of small lakes, known as Salmon Lakes, forming one of the sources of North Fork of Yuba River, have the sides bright red instead of purplish. The lower fins are of the same color as the sides, but edged with white. Some of the trout of Gold Lake, about a mile away from Salmon Lakes, but tributary to Middle Fork of Feather River, are red like those from Salmon Lakes; others have the ordinary color of typical *irideus*. The Gold Lake trout are badly infested with gill parasites.

The single specimen from Cliff Lake has but 116 cross rows of scales, which is also the number in the lateral line. The average number of scales for the 129 specimens counted is 147. The greatest variation in any one locality is 36, found in specimens from Sullaway Creek. Several stations have

a variety of 23 to 28. Excepting the one specimen from Cliff Lake with 116, the smallest number of scales recorded is 128, and the largest 176. The specimens from upper Sacramento and Pitt River regions average 147 scales, those from the various branches of Feather River average 143. From South Fork of Battle Creek, 163.

Local Distribution.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
West of Sierras			Salmo iridea	Jordan & Gilbert.
	Sacramento River		do	Jordan & Jouy.
	Gumboot Lake and other lakes of vicinity.	Rutter & Chamberlain.	do	
Sissons	Sacramento River	do	do	
Do	Sullaway Creek.	do	do	
Sims	Sacramento River	do	do	
Bartlets	McCloud River	do	do	
Big Bend	do	do	do	
Lower Falls	do	do	do	
		Stone	S. henshawi	Jordan & Henshaw.
			S. iridea	Bean.
Baird	do		do	Jordan & Gilbert.
		Stone	Salmo irideus stonei	Jordan, 1894.
			S. gairdneri shasta	do.
	Goose Lake	Rutter & Chamberlain.	S. iridea	
Davis Creek Post-Office	Davis Creek	do	do	
Near source of	North Fork Pitt River.	do	do	
Near Alturus	do	do	do	
South Fork Post-Office	South Fork Pitt River	do	do	
	Tributary of Pitt River	Henshaw	S. tsuppitch	Jordan & Henshaw.
Near Aden	Rush Creek	Rutter & Chamberlain.	S. iridea	
Cassel	Hat Creek	do	do	
Dana	Fall River	do	do	
Fall River Mills	do	do	do	
Near Bartlets	Bear Creek	do	do	
Burneyville	Burney Creek	do	do	
Battle Creek Meadows	Battle Creek	do	do	
Longs Ranch	do	do	do	
United States hatchery	do	Rutter	do	
Morgan Springs	Mill Creek	Rutter & Chamberlain.	do	
	Chico Creek	Newberry	Salar iridea	Girard, 1857.
Jacinto	Sacramento River	Rutter & Chamberlain.	Salmo iridea	
Princeton	do	do	do	
	Clear Lake	Jordan & Gilbert	Salmo mykiss irideus	Jordan & Gilbert.
Lake County	Allen Springs	Cleveland	Salmo iridea	Eigenmann & Eigenmann.
Martinez	Brook	Winslow	S. rivularius	Ayres, 1854–7.
Near source of	North Fork Feather River.	Rutter & Chamberlain.	S. iridea	
Johnsons	Warner Creek	do	do	
Big Meadows	Duck Lake	do	do	
Do	North Fork Feather River.	do	do	
Quincy	Spanish Creek	Rutter & Atkinson.	do	
Greenville	Wolf Creek	do	do	
Genesee Valley	Clover Creek	do	do	
Clover Valley	do	do	do	
Nelson Point	Middle Fork Feather River.	do	do	
	Gold Lake	do	do	
Sierraville	Cole Creek	do	do	
Near Sierra City	Three Salmon Lakes	do	do	
Bassett Hotel	Bassett Creek	do	do	
Near Grass Valley	Rattlesnake Creek	do	do	
Gerle	Rubicon River	do	do	
Orelli	Big Silver Creek	do	do	
Jones Ranch	Little Silver Creek	do	do	
Pleasant Valley	North Fork Consumne River.	do	do	
West Point	Middle Fork Mokelumne River.	do	do	
Railroad Flat	Licking Creek	do	do	
Do	South Fork Mokelumne River.	do	do	
Calaveras Grove	San Antonio Creek	do	do	
At mouth of	South Fork Tuolumne River.	do	do	
Bower Cave	North Fork Merced River	do	do	
Near source of	Kern River	Henshaw	Salmo iridea, Salmo tsuppitch.	Jordan & Henshaw.
Do	do	Gilbert	S. gairdneri gilberti	Jordan, 1894.
Near Mount Olanche	South Fork Kern River	Henshaw	S. pleuriticus	Jordan & Henshaw.

18a. Salmo aqua-bonita (Jordan). *Golden Trout of South Fork of Kern.*

Salmo mykiss aqua-bonita Jordan, Proc. U. S. Nat. Mus., 1892, p. 481, Volcano Creek.
Salmo irideus aqua-bonito Jordan & Evermann, Fishes N. & Mid. Amer., pt. I, p. 503, 1896.

We have seen but few specimens of this species.

19. Salvelinus malma (Walbaum). *Dolly Varden Trout.*

Salmo malma Walbaum, Artedi Piscium, p. 66, 1792, Kamchatka.
Salvelinus bairdii Bean, Proc. U. S. Nat. Mus., 1880, p. 707, McCloud River.
Salvelinus malma Jordan & Evermann, Fishes North & Mid. Amer., pt. I, p. 507, 1896.

Reported by Bean, 1880, and by various sportsmen from the McCloud River; not otherwise known from the basin.

20. Gasterosteus cataphractus (Pallas). *Stickleback.*

Gasterosteus cataphractus Pallas, Mem. Ac. Petersb., vol. III, 1811, p. 325, Kamchatka.
Gasterosteus microcephalus Girard, Proc. Ac. Nat. Sci. Phila., 1854, p. 133, Four Creeks, Tulare Valley.

The sticklebacks of California have been reported under various names, but only the name *microcephalus* has been applied to specimens from the Sacramento-San Joaquin Basin. Several other names have been given to specimens from San Francisco Bay and its smaller tributaries.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
	Rivers of California		Gasterosteus microcephalus	Jordan & Gilbert, 1881.
San Francisco			do	Jordan & Jouy.
United States hatchery.	Battle Creek	Rutter	Gasterosteus cataphractus.	
	Clear Lake	Jordan & Gilbert	Gasterosteus microcephalus	Jordan & Gilbert, 1894.
Centerville	Kings River	Rutter & Atkinson.	Gasterosteus cataphractus.	
	Four Creeks	Heermann	Gasterosteus microcephalus	Girard, 1854, 1857, 1859.
	Tulare Lake	do	do	Girard, 1854.

21. Archoplites interruptus (Girard). *Sacramento Perch.*

Centrarchus interruptus Girard, Proc. Ac. Nat. Sci. Phila., 1852, p. 129, San Joaquin and Sacramento rivers.
Centrarchus maculosus Ayres, Proc. Cal. Ac. Nat. Sci., vol. I, 1854, p. 8, Sacramento River.
Ambloplites interruptus Girard, Pac. Ry. Surv., vol. X, p. 10.
Archoplites interruptus Jordan & Evermann, Fishes N. & Mid. Amer., pt. I, p. 991, 1896.

Mouth large, oblique, the lower jaw projecting, the maxillary extending to below posterior portion of eye; eye large, 3.7 to 4.7 in head; dorsal with XII or XIII spines and 10 or 11 soft rays; anal VI, 10; scales strongly ctenoid. Color very variable; sometimes very dark with small pale blotches; or nearly plain silvery with two or three alternating rows of dusky blotches.

Rare, sometimes taken in marketable quantities near Rio Vista. An excellent food fish, formerly abundant, its disappearance charged to the introduction of carp and catfish, but probably due also to the reclamation of swamp lands.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
	Sacramento River	Heermann	Centrarchus interruptus	Girard, 1854.
San Francisco markets	do	Kennerly	Ambloplites interruptus	Girard, 1858.
Do	do	Ayres	Centrarchus maculosus	Ayres, 1854-7.
Do	do	Newberry	Ambloplites interruptus	Girard, 1857.
	do	Lockington	Archoplites interruptus	Lockington.
	do	(?)	do	Jordan & Jouy.
United States hatchery.	Battle Creek	Rutter	do	
	Clear Lake	Jordan & Gilbert	do	Jordan & Gilbert.
Sacramento	Sacramento River	Rutter & Chamberlain.	do	
Arcade	Arcade Creek	Rutter & Atkinson	do	
Rio Vista	Sacramento River	Rutter	do	
	San Joaquin River.	Ayres	Centrarchus maculosus	Ayres, 1854-7.
	do	Heermann	Ambloplites interruptus	Girard, 1854.
	Kern Lake, Tulare Valley.	Henshaw	do	Jordan & Henshaw.

22. Hysterocarpus traskii Gibbons. *Fresh-water Viviparous Perch.*

Hysterocarpus traskii, Gibbons, Proc. Ac. Nat. Sci. Phila., 1854, p. 105, lagoons of lower Sacramento River. Jordan & Evermann, Fishes N. & Mid. Amer., pt. I, p. 1496, 1898.
Sargosomus fluviatilis Agassiz, MS., Alexander Agassiz, Proc. Bost. Soc. Nat. Hist., vol. VIII, 1861, p. 1301, Sacramento River.
Docentrus lucens, Jordan, Bul. U. S. Geol. Surv. vol. IV, 1878, p. 667, Sacramento River, erroneously ascribed to Rio Grande.

Body deep and compressed, back strongly arched; mouth small, terminal, jaws even, maxillary not extending to eye; dorsal with about XVII spines and 11 soft rays; anal with 3 spines and 23 soft rays. Scales cycloid.

Not very abundant, found in sluggish water. Readily distinguished from the Sacramento perch or sunfish by the small mouth and cycloid scales.

LOCAL DISTRIBUTION.

Locality.	Stream or lake.	Collector.	Name as reported.	Authority.
San Francisco markets	Sacramento River		Hysterocarpus traskii	Jordan & Jouy. Eigenmann & Ulrey.
	do		Sargosomus fluviatilis.	A. Agassiz.
Fresh-water lagoons	do	Trask & Morris	H. traskii	Gibbons, 1854a, 1854b.
Pittville	Pitt River	Rutter & Chamberlain.	do	
Redding	Sacramento River	do	do	
Fort Redding	Cow Creek	Newberry	do	Girard, 1857–58.
Do	do	Henshaw	do	Girard, 1857–58.
United States hatchery	Battle Creek	Rutter & Scofield.	do	
Red Bluff	Sacramento River	do	do	
Vina	do	do	do	
Chico Bridge	do	do	do	
Jacinto	do	do	do	
Wilson Farm	do	do	do	
	Clear Lake	Jordan & Gilbert	do	Jordan & Gilbert.
Marysville	Feather River	Rutter & Chamberlain.	do	
Pollasky	San Joaquin River	Rutter & Atkinson	do	
Centerville	China Slough	do	do	
Do	Kings River	do	do	

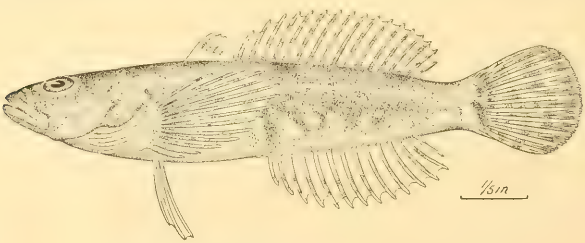


Fig. 3.—Cottus asperrima, new species. Type.

23. Cottus asperrima Rutter, new species.

Head 3.2 to 3.33 in length; depth 5.5; eye 3.5 to 4 in head; snout a little longer than eye; dorsal VI (or V), 18; anal 14; pectoral 14; ventral I, 3; caudal (branched rays) 7. Body slender, but not particularly compressed, width of caudal peduncle 1.25 to 1.33 in eye, its depth slightly greater than eye; maxillary 2.5 in head, extending to vertical through anterior edge of pupil; profile flat or concave back of eye; anterior nostrils with conspicuous tubes; upper preopercular spine slender, sharp, almost straight, directed slightly upward, partly covered by the skin; second much shorter, triangular, directed toward lower base of pectoral, sometimes rudimentary; third spine wanting; interorbital space 0.5 of eye; spinous dorsal low, its outline not so strongly arched as in *tenuis*, spines very weak, longest about equal to eye, only five in one specimen; longest soft ray of dorsal about 2 in head; origin of soft dorsal in or

behind middle of body; caudal convex, 1.33 to 1.43 in head; ventrals 1.6 in head, the rays graduated, the outer 0.66 length of inner; distance from snout to vent 0.54 to 0.56 of body. Fine prickles behind pectoral in all specimens, extending all over sides in two, and about half over in two others; lateral line ending under second to fifth ray from end of soft dorsal; finely mottled with dusky and gray, the dusky collecting into four or five blotches in some specimens; ventrals colorless, other fins barred.

Description based on five specimens 1.5 to 2.5 inches long from Fall River at Dana, Cal., collected by Rutter and Chamberlain. Another specimen 2.1 inches long was taken in Fall River at Fall River Mills. The latter specimen has stronger opercular spines, and the vent is but 0.52 of the body length from tip of snout. Type no. 58500, U. S. National Museum.

The following is a statement of the differences between this species and *Cottus tenuis*, as determined from the original description and drawing of the latter:

	C. asperrima.	C. tenuis.
Width of caudal peduncle into eye	1.25	[illegible]
Head into length	3.33	3.8
Depth into length	5.33	7
Distance of vent from snout	.55	.51
Distance of soft dorsal from snout	.53	.49
First ray of soft dorsal	Segmented.	Unsegmented.
Pectoral rays	14	15
Caudal rays (branched)	7	9
Caudal margin	Convex.	Concave.
Outer ventral ray	.66 of inner.	.9 of inner.
Preopercular spine	Less hooked.	

24. Cottus asper Richardson. *Sculpin.*

Cottus asper Richardson, Fauna Bor. Amer., 295, 1836, Columbia River, Fort Vancouver.
Cottopsis parvus Girard, Proc. Ac. Nat. Sci. Phila., 1854, p. 144, Presidio.
Uranidea semiscaber centropleura Eigenmann & Eigenmann, West American Naturalist, 1889, p. 149, Allen Springs, Lake County.
Cottus gulosus (in part) Jordan & Evermann, Fishes N. & Mid. Amer., pt. II, p. 1945, 1898.

Body entirely asperate in all specimens of our collection. The following table indicates the variation in fin rays:

Locality.	Number of specimens having— Dorsal— VII	VIII.	IX.	20.	21.	Anal— 16.	17.	18.	19.
Sacramento River, Redding	2			1	1		1		1
Mouth of Battle Creek		1		1			1		
Sacramento River, Red Bluff		1			1			1	
Sacramento River, Jacinto		1		1			1		
Feather River, Marysville			1	1			1		
Arcade Creek, Arcade		6	3	8	1	1	5	3	

Local Distribution.

Locality.	Stream.	Collector.	Name as reported.	Authority.
Redding	Sacramento River	Rutter & Chamberlain.	Cottus asper	
Fort Reading	do	Hammond	Cottopsis parvus	Girard, 1858.
Red Bluff	do	Rutter & Scofield	Cottus asper	
Jacinto	do	do	do	
Chico Bridge	do	do	do	
Jacinto	do	do	do	
Lake County	Allen Springs	Cleveland	Uranidea semiscaber.	Eigenmann & Eigenmann.
Marysville	Feather River	Rutter & Chamberlain.	Cottus asper	
Arcade	Arcade Creek	Rutter & Atkinson	do	
Mare Island	San Pablo Bay		do	Jordan & Jouy.

25. Cottus gulosus (Girard). *Sculpin; Bull-head.*

Cottopsis gulosus Girard, Proc. Ac. Nat. Sci. Phila., 1854, p. 129, San Mateo Creek.
Uranidea gulosa Jordan & Henshaw, Wheeler Survey, 1878, p.199.
Cottus shasta Jordan & Starks, Proc. Cal. Ac. Sci. 1896, 224, McCloud River.
Cottus gulosus (in part) Jordan & Evermann, Fishes N. & Mid. Amer., pt. II, p. 1944, 1898.

A widely distributed and somewhat variable species. Found throughout the basin. Specimens from Stanislaus River, Parrot Ferry, American River near Placerville, Feather River at Oroville, Warner Creek, Battle Creek at the government hatchery, McCloud River at Baird, and Sacramento River at Sims, have teeth on the palatines which are wanting in specimens from other places, and in some of the specimens from the places just mentioned. The patch of prickles behind pectoral fins is universally present. The opercular spines are variously developed; one is always present at lower end of subopercle; and one is always present at upper corner of preopercle. The two lower preopercular spines may or may not be developed; usually they are mere rounded projections and covered by the skin. When present the second preopercular spine projects downward; this is especially noticeable in the specimens from Warner Creek. The dorsal fins are continuous or very slightly joined. The size of the eye is somewhat variable.

LOCAL DISTRIBUTION.

Locality.	Stream.	Collector.	Name as reported.	Authority.
San Francisco			Cottopsis gulosus	Jordan & Jouy.
	Upper Pitt River	Newberry	do	Girard, 1857.
At mouth	Joseph Creek	Rutter & Chamberlain.	Cottus gulosus	
Jess Valley	South Fork Pitt River	Henshaw	Uranidea gulosa	Jordan & Henshaw.
South Fork Post-office	do	Rutter & Chamberlain.	Cottus gulosus	
Canby	Pitt River	do	do	
Near Aden	Rush Creek	do	do	
Fall River Mills	Fall River	do	do	
Dana	do	do	do	
Cassel	Hat Creek	do	do	
Burneyville	Burney Creek	do	do	
Sisson	Sullaway Creek	do	do	
Do	Sacramento River	do	do	
Sims	do	do	do	
Baird	McCloud River	do	do	
Do	do		do	Jordan & Jouy.
Do	do	Starks	Cottus shasta	Jordan, 1896.
United States hatchery	Battle Creek	Rutter & Scofield	Cottus gulosus	
Oroville	Feather River	Rutter & Chamberlain.	do	
Johnsons	Warner Creek	do	do	
	Clear Lake	Jordan & Gilbert	do	Jordan & Gilbert.
Placerville	American River	Rutter & Chamberlain.	do	
	San Joaquin River	Heermann	Cottopsis gulosus	Girard, 1854.
Parrot Ferry	Stanislaus River	Rutter & Atkinson	Cottus gulosus	

26. Cottus macrops Rutter, new species.

Head 3.1; depth 4.33; eye large, 3.3 to 3.6 in head; dorsal VII or VIII, 19; anal 13 or 14; ventral I, 4. Body heavy, head large, the snout broader than in *klamathensis;* maxillary not quite reaching vertical at front of pupil, its length 2.5 in head; teeth in jaws and on vomer, none on palatines; those on sides of jaws weak, extending on upper jaw only about half way to corner of mouth; anterior nostrils in short tubes; the posterior nostrils without tubes, smaller than the mucous pores; mucous pores arranged as in *klamathensis*, two pairs above front of eyes, a single median pore posteriorly between orbits and a circle of pores behind each eye; other pores posteriorly on head; interorbital narrow, about one-half of orbit, the bony septum about one-third; top of head behind eye very slightly concave; opercular spines small, sharp; lower spines of preopercle wanting; lower spine of subopercle sharp, smaller than upper spine of preopercle, which is curved upward; tip of opercle flat, rounded; spinous dorsal low, its spines about 6. Height of soft rays, which are equal to snout and half of eye, about the same as in *klamathensis*, the two fins broadly joined for from one-third to two-thirds the height of the spinous portion. Depth and length of caudal peduncle about equal; caudal fin 1.4 to 1.6 in head, truncate or slightly rounded except when widely spread, divided rays 8, sometimes 9; length of pec-

toral 0.26 to 0.29 of body, about reaching front of anal, the upper rays but little graduated, the eighth to twelfth from bottom nearly even, the upper ray 1.75 to 1.8 in longest (2 to 2.5 in *klamathensis* and 2 to 2.5 in *gulosus*). The variation in fin rays is shown in the following table:

Locality.	Number of specimens having— Spinous dorsal.		Soft dorsal.			Anal.		
	VII.	VIII.	18.	19.	20.	13.	14.	15.
Dana	15	4	3	13	3	5	12	2
Fall River Mills	1	1	....	2	....	....	2	....

Skin without prickles. Lateral line not extending beyond middle of soft dorsal. Color brownish olive with 5 or 6 dusky blotches on sides, one being at base of caudal; all fins dusky, except sometimes the ventrals; a black blotch on posterior part of spinous dorsal, a more or less brownish or dusky blotch in front of base of pectorals; all soft fins vertically barred; one or two dusky bars downward and backward from eye.

This species is most closely related to *klamathensis*, but is a heavier fish, the eye is larger, the head not so pointed, and the dorsal is inserted slightly more posteriorly. In five specimens of each species, of equal sizes, the distance from the snout to dorsal was in *macrops* 0.37, 0.38, 0.38, 0.38, and 0.39 of

Fig. 4.—Cottus macrops, new species. Type.

the body length, while in *klamathensis* the same measurements were 0.36, 0.36, 0.36, 0.365, and 0.365. It differs from *gulosus*, with which it is found, in the above characters, besides having a more broadly rounded pectoral, incomplete lateral line, and a skin entirely free from prickles.

Known only from Fall River, where it is associated with *Cottus gulosus* and *Cottus asperrima*, but more common than either. Here described from 19 specimens from Fall River at Dana, collected by Rutter and Chamberlain, the largest specimen being 2.8 inches long. Named with reference to the large eyes. Type no. 58499, U. S. National Museum.

27. Cottus beldingii Eigenmann & Eigenmann.

Cottus beldingii Eigenmann & Eigenmann, Amer. Nat., vol. xxv, 1891, p. 1132, Lake Tahoe and Dormer Lake. Jordan & Evermann, Fishes N. & Mid. Amer., pt. II, p. 1958, 1898.

A Truckee Basin species with entirely smooth skin, no palatine teeth and short fins. Found in only one locality in the Sacramento Basin, Cole Creek near Sierraville, where it was collected by Rutter and Chamberlain. Fin rays as follows:

	Specimens.		Specimens.
Dorsal:		Dorsal:	
Spines		Rays—	
VI	2	19	1
VII	17	Anal:	
VIII	2	12	8
Rays		13	12
17	5	14	1
18	12		

SUMMARY ON DISTRIBUTION.

Of the 27 species listed above, 14 are limited to California; 6 (*Entosphenus tridentatus, Lampetra cibaria, Salmo irideus, Salvelinus malma, Gasterosteus cataphractus*, and *Cottus asper*) have more or less ability to withstand sea water and are not of interest when studying the distribution of fresh-water fishes.

Of the 22 strictly fresh-water species, 12 (*Catostomus occidentalis, Orthodon microlepidotus, Lavinia exilicauda, Mylopharodon conocephalus, Pogonichthys macrolepidotus, Ptychocheilus grandis, Leuciscus crassicauda, Leuciscus conformis, Rutilus symmetricus, Archoplites interruptus, Hysterocarpus traskii*, and *Cottus gulosus*) are typical of and have a wide distribution in the basin; 3 (*Catostomus microps, Cottus asperrima*, and *Cottus macrops*) are limited in distribution and known only from their type localities; *Rutilus bicolor* is common to Pitt River drainage and to the lakes and streams of southern Oregon; and 5 (*Pantosteus lahontan, Catostomus tahoensis, Leuciscus egregius, Agosia robusta*, and *Cottus beldingii*) are Nevada species that have crossed the Sierras into the Sacramento-San Joaquin Basin.

The last 6 mentioned need particular notice.

Besides being widely distributed in the Pitt River region, *Rutilus bicolor* is exceedingly abundant in Wolf Creek (<Indian Creek <North Fork Feather River), Indian Valley. The connection between this stream and Pitt River is not very close, as they are tributary to the Sacramento at points about 300 miles apart.

Agosia robusta is the only one of the Nevada species that has become widely distributed west of the Sierras.

Leuciscus egregious is limited to the vicinity of Big Meadows (headwaters of North Fork of Feather River), and to one locality on the opposite side of the basin near Clear Lake.

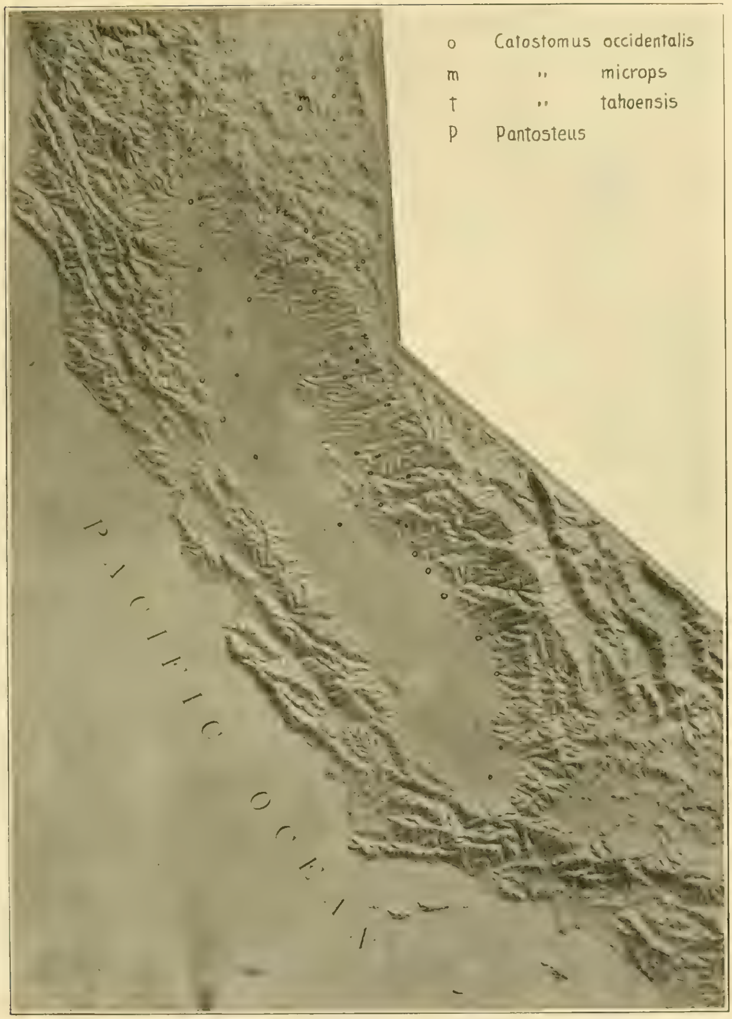
Catostomus tahoensis has been found only in the vicinity of Big Meadows and in Sierra Valley, though the streams connecting these two places have been fished in several places.

Pantosteus lahontan has been found only in Big Meadows vicinity.

Cottus beldingii only in Cole Creek, tributary to Sierra Valley.

The Big Meadows region has 4 Nevada species, Sierra Valley 3, 2 being common to both. The former has 2 not found in the latter, and the latter has 1 not found in the former. It seems probable that there have been at least two migrations from the Lahontan drainage into the Sacramento, though there is need of more data on that point.

The following table indicates the distribution according to the above summary. By Lahontan division is meant the Big Meadows and Sierra Valley regions. The Sacramento division includes the whole basin except that included in the Lahontan and Pitt River regions.



TOPOGRAPHICAL MAP SHOWING DISTRIBUTION OF THE CATOSTOMIDÆ IN THE SACRAMENTO-SAN JOAQUIN BASIN.

Distribution of Freshwater Fishes in Sacramento-San Joaquin Basin.

Species.	Basin divisions.			
	Pitt River.	Lahontan.	Sacramento.	Found only in California.
1. Entosphenus tridentatus	×	....	×	....
2. Lampetra cibaria	[illegible]	[illegible]	[illegible]	[illegible]
3. Pantosteus lahontan	[illegible]	[illegible]	[illegible]	[illegible]
4. Catostomus microps	×	[illegible]	[illegible]	[illegible]
5. Catostomus tahoensis	[illegible]	[illegible]	[illegible]	[illegible]
6. Catostomus occidentalis	×	×	×	×
7. Orthodon microlepidotus	....	....	×	×
8. Lavinia exilicauda	[illegible]	[illegible]	[illegible]	[illegible]
9. Mylopharodon conocephalus	[illegible]	[illegible]	[illegible]	[illegible]
10. Pogonichthys macrolepidotus	[illegible]	[illegible]	[illegible]	[illegible]
11. Ptychocheilus grandis	×	....	×	×
12. Leuciscus crassicauda	....	....	×	×
13. Leuciscus conformis	....	....	×	×
14. Leuciscus egregius	[illegible]	[illegible]	[illegible]	[illegible]
15. Rutilus bicolor	[illegible]	[illegible]	[illegible]	[illegible]
16. Rutilus symmetricus	[illegible]	[illegible]	[illegible]	[illegible]
17. Agosia robusta	[illegible]	[illegible]	[illegible]	[illegible]
18. Salmo irideus	[illegible]	[illegible]	[illegible]	[illegible]
19. Salvelinus malma	[illegible]	[illegible]	[illegible]	[illegible]
20. Gasterosteus cataphractus	[illegible]	[illegible]	[illegible]	[illegible]
21. Archoplites interruptus	[illegible]	[illegible]	[illegible]	[illegible]
22. Hysterocarpus traskii	[illegible]	[illegible]	[illegible]	[illegible]
23. Cottus asperrimus	[illegible]	[illegible]	[illegible]	[illegible]
24. Cottus asper	[illegible]	[illegible]	[illegible]	[illegible]
25. Cottus gulosus	×	×	×	....
26. Cottus macrops	[illegible]	[illegible]	[illegible]	[illegible]
27. Cottus beldingii	[illegible]	[illegible]	[illegible]	[illegible]
Total	13	8	21	14
Limited to one division	3	3	10	

SUMMARY OF VARIATIONS.

The following species deserve special notice on account of their remarkable variations:

Catostomus occidentalis varies in scales of lateral line from 60 to 84, and in rays of dorsal from 11 to 14. The size of the lips varies enormously, being almost twice as great in some localities as in others.

Lavinia exilicauda. The only important variation in this species is in the presence or absence of the horny sheath of the lower jaw.

Ptychocheilus grandis. The scales of the lateral line vary from 65 to 78, or, if *Ptychocheilus harfordi* be included, from 65 to 88.

Rutilus bicolor has the number of scales of the lateral line ranging from 44 to 61; but its greatest variation is in the shape of the head, which varies from triangular (side view) to quadrangular.

Rutilus symmetricus is the most variable species of the basin. The number of scales varies from 47 to 56; the lower jaw may or may not have a horny sheath, which is developed irrespective of age, sex, season, or locality; the shape of the head, depth of caudal peduncle, size of eye, length of fins, and general appearance all vary

greatly. In certain localities more or less isolated some of these variations are so correlated that the forms would readily be taken for distinct species or even genera were not intermediate forms found in other equally isolated localities.

Agosia robusta varies greatly in scales of lateral line (49 to 77), length of fins, development of barbel and lateral line, and general shape of body and head.

Salmo irideus varies greatly in number of scales, 116 to 176 cross rows. There are almost as many variations in color as there are streams.

ANADROMOUS SPECIES.

Oncorhynchus gorbuscha (Walbaum). *Humpback Salmon.*

Reported from the Sacramento River by Jordan & Gilbert. Not otherwise known from the basin.

Oncorhynchus keta (Walbaum). *Dog Salmon.*

Very rare. One or two seen each year at the canneries and hatcheries.

Oncorhynchus tschawytscha (Walbaum).[a] *Sacramento Salmon.*

By far the most important fish of the basin. Ascends the river in two distinct runs, one in May and June, the other in September, though a few fish may be found in the river at any time of the year. The principal spawning streams, named in the order of their importance, are: The main river between Chico and Redding, Battle Creek, McCloud River, upper Sacramento River (above mouth of Pitt River), Hat Creek, and Fall River. The importance of Pitt River below the falls as a spawning stream is unknown. A few salmon pass up Feather River and most of the other tributaries. The spring run spawns in August, the fall run in November. The young of this species begin their seaward migration as soon as they are able to swim and reach the ocean when 4 or 5 months old, though a few remain in the headwaters until they are 6 to 12 months old.

Oncorhynchus kisutch (Walbaum). *Silver Salmon.*

Reported by Jordan & Jouy, 1881, from the Sacramento River, but not otherwise known from the basin.

Salmo gairdneri (Richardson). *Steelhead.*

Reported from the Sacramento River by Jordan & Gilbert, 1881. If it is found in the basin we have been unable to distinguish it from the rainbow trout. A specimen weighing 7½ pounds, taken at Battle Creek hatchery in November, 1897, was identified by us as *Salmo irideus*. Scales in lateral line (not cross rows) 129.

Osmerus thaleichthys Ayres.

Taken in fresh water at Walnut Grove and Collinsville. The adults go up the river to spawn during February, the young come down during April.

[a] For a more complete account of this fish see Rutter, Natural history of the quinnat salmon, Bulletin U. S. Fish Comm., vol. XXII, 1902, p. 65–141.

INTRODUCED SPECIES.

A review of the history and results of the attempts to acclimatize fish and other water animals in the Pacific States is given by Dr. H. M. Smith in the Bulletin of the U. S. Fish Commission, vol. xv, 1895, p. 379–472. Thirty species are mentioned in this report. The following is a list of those planted in our territory:

Page.	Species.	Common name.	Page.	Species.	Common name.
382	Ameiurus catus	Common catfish.	438	Lucius lucius	Pike.
	Ameiurus nebulosus	Bullhead.		Anguilla chrysops	Eel.
	Ictalurus punctatus	Channel catfish	441	Ambloplites rupestris	Sunfish.
393	Cyprinus carpio	Carp.		Chænobryttus gulosus	Sunfish.
403	Chanos cyprinella			Lepomis cyanellus	Sunfish.
404	Clupea sapidissima	Shad.		Lepomis pallidus	Sunfish.
428	Coregonus clupeiformis	Whitefish.	442	Micropterus dolomieu	Small-mouthed black bass.
430	Salmo salar	Atlantic salmon.		Micropterus salmoides	Large-mouthed black bass.
431	Salmo salar sebago	Landlocked salmon.	447	Perca flavescens	Perch.
433	Salmo fario		448	Stizostedion vitreum	Pickerel.
	Salmo trutta levenensis	Loch Leven trout.	449	Roccus lineatus	Striped bass.
	Salvelinus fontinalis	Eastern brook trout.		Roccus chrysops	Rock bass.

Fortunately only a few of the 24 species mentioned above have obtained a foothold in California waters. The following, and possibly others, are now a portion of the fish fauna of the state.

Ameiurus catus (Linnæus). *Common Catfish.*

Introduced from eastern waters and now exceedingly abundant in the lower rivers and in brackish water. Distinguished from *A. nebulosus* by the deeply emarginate caudal fin. Observed in the Sacramento River at Red Bluff, Jacinto, Knights Landing, mouth of Feather River, Sacramento, Walnut Grove, Ryde, Rio Vista, and Benicia, also in the San Joaquin at Antioch, and in Carquinez Straits. Reported by Jordan & Gilbert from Clear Lake.

Ameiurus nebulosus (Le Sueur). *Bullhead Catfish.*

Introduced into the streams of the state along with *A. catus*. Distinguished by the truncate or rounded caudal fin.

Taken in Sacramento River at Knights Landing, Arcade Creek at Arcade, South Fork Dry Creek near Grass Valley, Carquinez Straits at Benicia, and in China Slough and Kings River near Centerville. Reported by Jordan & Gilbert from Clear Lake. In the lower Sacramento much less common than *Ameiurus catus.*

Cyprinus carpio (Linnæus). *Carp.*

A Chinese fish introduced into California from Germany, Japan, and the eastern states. For a history of the carp in California see "A review of the history and results of the attempts to acclimatize fish and other water animals in the Pacific States," by Hugh M. Smith, Bulletin U. S. Fish Commission, vol. xv, 1895, p. 379–472.

The carp is now abundant in the quiet waters throughout the lower portion of the basin, even entering brackish water. It is a sluggish fish, little esteemed as food, and an important source of food for cormorants and striped bass. Said to be less common in the Sacramento River between Red Bluff and Redding than it was a few years ago.

Observed at the following places: In Sacramento River at mouth of Pitt River, Redding, mouth of Clear Creek, Battle Creek hatchery, Red Bluff, Vina, Jacinto, Knights Landing, mouth of Feather River, Sacramento, Ryde, Rio Vista, Collinsville; in Wolf Creek near Greenville, Arcade Creek at Arcade, China Slough at Centerville, San Joaquin River at Antioch, and in Carquinez Straits at Benicia. It is one of the few of its family that can withstand strongly brackish water.

Alosa sapidissima (Wilson). *Shad.*

Introduced in 1871 and now abundant. The young were taken at the following localities in the Sacramento River in May, 1898: Chico Bridge, Butte City, Princeton, Colusa, Grimes, Wilson's Farm, 20 miles below Grimes, Sacramento, and Collinsville.

Micropterus dolomieu (Lacépède). *Small-mouthed Black Bass.*

Introduced into various lakes in the state. Reported from Clear Lake by Jordan & Gilbert, 1894. Reported by sportsmen from Sacramento River near Sacramento.

Roccus lineatus (Bloch). *Striped Bass.*

Introduced into the waters of California in 1879 and now abundant. The young taken as far up the river as Knights Landing.

THE FISHES OF THE COASTAL STREAMS OF OREGON AND NORTHERN CALIFORNIA

By JOHN OTTERBEIN SNYDER
Assistant Professor of Zoology, Leland Stanford Junior University

BUREAU OF FISHERIES DOCUMENT NO. 638

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INTRODUCTION.

The present paper contains an account of the fish fauna of the smaller coastal streams of Oregon and northern California which have their origin west of the Sierra-Cascade Mountain system and drain a section of the coast extending from the Columbia River to the Sacramento. All of the streams reaching the ocean between the Columbia and Sacramento are therefore included except the Klamath, which rises in the high table-lands east of the Cascade Mountains.

The material was collected during a series of field investigations conducted under the auspices of the Bureau of Fisheries for the general purpose of studying the fish fauna of this region.[a] The study of a collection made by Messrs. Frank Cramer and Keinosuke Otaki in the basins of the Rogue, Willamette, and Umpqua rivers is also embodied in this report. Many specimens from the lake region of Oregon, and from the Columbia, Klamath, and Sacramento basins have been kindly furnished for examination by Dr. B. W. Evermann.

LOCAL DISTRIBUTION OF THE FISH FAUNA.

The coast region of Oregon and northern California is one of great rainfall, the quantity of rain increasing to the northward, where streams draining even the smallest basins have an unusually large and constant volume. Apparently every condition favorable to the support of a rich fauna prevails, and the streams in many places fairly swarm with fishes. The number of species is remarkably small, however, and those present consist mostly of anadromous forms such as the sturgeon, salmon, and trout, together with others able to withstand salt water, as the cottoids and sticklebacks. Only 11 species of strictly fluvial fishes have been found in the smaller coastal streams, 7 of which occur in the rivers north of the Klamath.

[a] The work was under the general supervision of Dr. C. H. Gilbert, of Stanford University. During June and July, 1897, a party consisting of Dr. Gilbert, A. G. Maddren, G. B. Culver, and J. O. Snyder explored the region south of the Rogue River. From July until late in September, 1899, a second party, including W. F. Allen, J. S. Burcham, E. C. Robinson and J. O. Snyder, students of Stanford University, extended the survey northward to the Columbia. Side excursions from the main line of work were frequently made to examine tributaries of the Columbia, Klamath, and Sacramento rivers. The writer has been very materially aided both in field explorations and laboratory studies by Dr. C. H. Gilbert, to whom he wishes to express his deep obligation for direction, advice, and friendly criticism. Great credit is also due to the several field assistants whose hearty cooperation has made this investigation possible.

Not only are the species few in number, but their distribution is very irregular, there being as many as 4 or 6 forms in some streams, while in others equally large there are but 1 or 2 or even none at all.

Following the coastal streams southward in serial order from the Columbia, and enumerating those which have a fluvial fish fauna, they are found to contain species as follows: Nehalem, *Catostomus macrocheilus;* Nestucca, *Agosia nubila;* Yaquina, *A. nubila;* Siuslaw, *C. macrocheilus, Ptychocheilus umpquæ, Leuciscus balteatus, A. nubila;* Tsiltcoos, *C. macrocheilus, P. umpquæ, L. balteatus;* Takenitch, *P. umpquæ, L. balteatus;* Umpqua, *C. macrocheilus, P. umpquæ, L. balteatus, Rheinichthys evermanni, Hybopsis crameri, A. nubila;* Coos, *C. macrocheilus, A. nubila;* Coquille, *C. macrocheilus, A. nubila;* Flores, *C. macrocheilus;* Sixes, *C. macrocheilus;* Rogue, *Catostomus rimiculus;* Mad, *Catostomus humboldtianus;* Eel, *C. humboldtianus;* Bear, *C. humboldtianus;* Navarro, *Rutilus symmetricus;* Gualala, *R. symmetricus;* Russian River, *Catostomus occidentalis, Mylopharodon conocephalus, Ptychocheilus grandis, R. symmetricus.*

No great difficulty has been met in determining the relationships of these species. They are representatives of forms found either in the Columbia, Klamath, or Sacramento rivers.[a] Some are identical in every respect with the species of the larger basins, while others show a varying degree of differentiation, as described in the following pages. In no case, however, does the relationship appear doubtful. One stream only, the Rogue, contains a Klamath form. North of the Rogue the fluvial species are representatives of the Columbia fauna, while south of the Klamath they belong with the Sacramento. This interesting condition of distribution is graphically shown on the appended map, where rivers having representatives of the Columbia fauna are outlined in red, the Klamath in green, and the Sacramento in orange. Rivers in which fluvial fishes are not known to occur are traced in black.

The following species are described as new: *Catostomus humboldtianus; Ptychocheilus umpquæ; Rhinichthys evermanni; Hybopsis crameri.*

A table has been prepared to show where specimens of each form have been collected, thus avoiding the long catalogue of localities which would otherwise appear after each species. The trout and salmon are not included in the table.

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[a] *Rhinichthys evermanni* is a possible exception. It does not appear to be closely related to *R. dulcis* of the Columbia. The genus does not occur in the Klamath or Sacramento. Reference may also be made to the well-known fact that the Columbia, Klamath, and Sacramento basins have each a distinctive fluvial fish fauna, consisting in many cases of characteristic species and genera.

TABLE SHOWING THE DISTRIBUTION OF SPECIES.

Locality.	Entosphenus tridentatus (Gairdner).	Acipenser medirostris Ayres.	Catostomus rimiculus Gilbert & Snyder.	Catostomus occidentalis Ayres.	Catostomus humboldtianus, new species.	Catostomus snyderi Gilbert.	Catostomus macrocheilus Girard.	Acrocheilus alutaceus Agassiz & Pickering.	Lavinia exilicauda Baird & Girard.	Mylopharodon conocephalus (Baird & Girard).	Mylocheilus lateralis Agassiz & Pickering.	Ptychocheilus grandis (Ayres).	Ptychocheilus oregonensis (Richardson).	Ptychocheilus umpquæ, new species.	Leuciscus caurinus Richardson.	Leuciscus bicolor (Girard).	Leuciscus balteatus (Richardson).
Columbia River fauna.																	
Columbia system:																	
Willamette River, Oregon City	×						×										
Clear Creek near Oregon City	×						×				×		×				×
Willamette River, Albany							×	×			×						×
Santiam Canal, Albany							×										×
Callapooya Creek near Albany							×	×			×		×				×
The Lakes near Albany							×										×
Willamette River near Corvallis							×	×			×		×				×
Willamette River near Junction City							×										
Long Tom Creek near Monroe							×				×		×				×
McKenzie River near Eugene	×						×						×				×
Willamette River near Eugene	×						×						×				×
Coast Fork, Cottage Grove							×	×					×				×
Row River, Cottage Grove													×				×
Nehalem River							×										
Tillamook River																	
Trask River																	
Nestucca River	×																
Siletz River																	
Little Elk and Yaquina River																	
Alsea River																	
South Fork, Alsea River																	
North Fork, Alsea River																	
Siuslaw River and Lake Creek							×										×
Lake Creek, Deadwood							×										×
Lake Creek near Loon Lake							×										×
Tsiltcoos River																	
Takenitch Creek																	×
Umpqua system:																	
South Umpqua River, Roseburg	×						×										
North Umpqua River, Winchester	×						×										
Elk Creek, Drain							×										
Callapooia Creek, Oakland							×										
South Umpqua, Canyonville							×										
Cow Creek							×										
Deer Creek near Roseburg							×										
South Fork Coos River							×										
North Fork Coquille River							×										
Coquille River, Myrtle Point							×										
Coquille River at South Fork																	
Coquille River at Middle Fork							×										
Flores Creek							×										
Sixes River							×										
Elk Creek, Curry County																	
Klamath River fauna.																	
Rogue River system:																	
Rogue River near mouth	×		×														
South Fork Illinois River, Josephine			×														
Deer Creek, Josephine County, Oreg.																	
Rogue River, Grants Pass			×														
Butte Creek, Central Point																	
Butte Creek, Eagle Point																	
Bear Creek near Central Point																	
Bear Creek near Ashland																	
Pistol River																	
Smith River																	
Klamath River system:																	
Klamath River near mouth	×															×	
Hunters Creek, Klamath																	
Shasta River, Montague																	
Shasta River, Yreka																	

TABLE SHOWING THE DISTRIBUTION OF SPECIES—Continued.

Locality.	Entosphenus tridentatus (Gairdner).	Acipenser medirostris Ayres.	Catostomus rimiculus Gilbert & Snyder.	Catostomus occidentalis Ayres.	Catostomus humboldtianus, new species.	Catostomus snyderi Gilbert.	Catostomus macrocheilus Girard.	Acrocheilus alutaceus Agassiz & Pickering.	Lavinia exilicauda Baird & Girard.	Mylopharodon conocephalus (Baird & Girard).	Mylocheilus lateralis Agassiz & Pickering.	Ptychocheilus grandis (Ayres).	Ptychocheilus oregonensis (Richardson.)	Ptychocheilus umpquæ, new species.	Leuciscus caurinus Richardson.	Leuciscus bicolor (Girard).	Leuciscus balteatus (Richardson).
Sacramento River fauna.																	
Redwood Creek, Orick																	
Mad River																	
Maple Creek																	
Little River																	
Elk River																	
Van Duzen Creek																	
South Fork Eel River near Garberville	×																
South Fork Eel River, Garberville	×																
Spawl Creek																	
Bear River, Capetown																	
Mattole River near mouth																	
Mattole River, White Thorn																	
Usal Creek																	
Ten-Mile River																	
Noyo River																	
Big River																	
South Fork Big River																	
Albion River																	
Navarro River near mouth																	
Navarro River near Philo																	
Navarro River near Boonville																	
Alder Creek																	
Garcia River near mouth																	
Garcia River 5 miles from mouth																	
Garcia River 10 miles from mouth																	
Gualala River at North Fork																	
Gualala River at Wheatfield Fork																	
Wheatfield Fork, Gualala																	
Russian River system:																	
Roberts Creek												×					
Russian River, Ukiah												×					
Warm Springs Creek										×		×					
Dry Creek, Skaggs Springs										×							
Dry Creek, Healdsburg										×		×					
Russian River, Healdsburg										×		×					
Knights Valley Creek										×		×					
Napa River, Rutherford																	
Napa River, Calistoga	×								×			×					
Conn Creek												×					

TABLE SHOWING THE DISTRIBUTION OF SPECIES—Continued.

Locality.	Rutilus symmetricus (Baird & Girard).	Rutilus bicolor (Girard).	Rhinichthys dulcis (Girard).	Rhinichthys evermanni, new species.	Agosia nubila (Girard).	Agosia klamathensis Evermann & Meek.	Agosia falcata Eigenmann & Eigenmann.	Hybopsis crameri, new species.	Coregonus williamsoni Girard.	Columbia transmontana Eigenmann & Eigenmann.	Gasterosteus cataphractus (Pallas).	Hysterocarpus traski Gibbons.	Cottus asper Richardson.	Cottus gulosus (Girard).	Cottus klamathensis Gilbert.	Cottus aleuticus Gilbert.	Cottus rhotheus Rosa Smith.
Columbia River fauna.																	
Columbia system:																	
Willamette River, Oregon City																	
Clear Creek near Oregon City																	
Willamette River, Albany																	
Santiam Canal, Albany																	
Callapooya Creek near Albany																	
The Lakes near Albany																	
Willamette River near Corvallis																	
Willamette River near Junction City																	
Long Tom Creek near Monroe																	
McKenzie River near Eugene			X		X												
Willamette River near Eugene								X									
Coast Fork, Cottage Grove					X												
Row River, Cottage Grove					X									X			
Nehalem River														X			
Tillamook River														X			
Trask River														X			
Nestucca River														X			
Siletz River														X			
Little Elk and Yaquina River														X			
Alsea River														X			
South Fork, Alsea River														X			
North Fork, Alsea River														X			
Siuslaw River and Lake Creek														X			
Lake Creek, Deadwood														X			
Lake Creek near Loon Lake														X			
Tsiltcoos River													X				
Takenitch Creek																	
Umpqua system:																	
South Umpqua River, Roseburg				X				X									
North Umpqua River, Winchester																	
Elk Creek, Drain																	
Callapooia Creek, Oakland																	
South Umpqua, Canyonville																	
Cow Creek																	
Deer Creek near Roseburg																	
South Fork Coos River																	
North Fork Coquille River																	
Coquille River, Myrtle Point																	
Coquille River at South Fork																	
Coquille River at Middle Fork																	
Flores Creek																	
Sixes River																	
Elk Creek, Curry County																	
Klamath River fauna.																	
Rogue River system:																	
Rogue River near mouth													X				
South Fork Illinois River, Josephine																	
Deer Creek, Josephine County, Oreg.																	
Rogue River, Grants Pass																	
Butte Creek, Central Point																	
Butte Creek, Eagle Point																	
Bear Creek near Central Point																	
Bear Creek near Ashland																	
Pistol River													X				
Smith River													X				
Klamath River system:																	
Klamath River near mouth													X				
Hunters Creek, Klamath													X				
Shasta River, Montague		X				X											
Shasta River, Yreka																	

TABLE SHOWING THE DISTRIBUTION OF SPECIES—Continued.

Locality.	Rutilus symmetricus (Baird & Girard.)	Rutilus bicolor (Girard).	Rhinichthys dulcis (Girard).	Rhinichthys evermanni, new species	Agosia nubila (Girard).	Agosia klamathensis Evermann & Meek.	Agosia falcata Eigenmann & Eigenmann.	Hybopsis crameri, new species.	Coregonus williamsoni Girard.	Columbia transmontana Eigenmann & Eigenmann.	Gasterosteus cataphractus (Pallas).	Hysterocarpus traski Gibbons.	Cottus asper Richardson.	Cottus gulosus (Girard).	Cottus klamathensis Gilbert.	Cottus aleuticus Gilbert.	Cottus rhotheus Rosa Smith.
Sacramento River fauna.																	
Redwood Creek, Orick											×						
Mad River											×						
Maple Creek											×					×	
Little River																	
Elk River											×						
Van Duzen Creek											×						
South Fork Eel River near Garberville											×						
South Fork Eel River, Garberville																	
Spawl Creek																	
Bear River, Capetown											×						
Mattole River near mouth											×						
Mattole River, White Thorn											×						
Usal Creek											×					×	
Ten Mile River											×		×				
Noyo River											×		×				
Big River											×		×				
South Fork Big River											×						
Albion River											×		×			×	
Navarro River near mouth											×		×			×	
Navarro River near Philo											×						
Navarro River near Boonville											×			×			
Alder Creek											×		×			×	
Garcia River near mouth											×		×			×	
Garcia River 5 miles from mouth											×		×			×	
Garcia River 10 miles from mouth											×						
Gualala River at North Fork											×		×				
Gualala River at Wheatfield Fork											×		×			×	
Wheatfield Fork, Gualala											×						
Russian River system:																	
Roberts Creek											×						
Russian River, Ukiah											×	×					
Warm Springs Creek														×			
Dry Creek, Skaggs Springs											×						
Dry Creek, Healdsburg											×	×					
Russian River, Healdsburg											×						
Knights Valley Creek												×					
Napa River, Rutherford											×						
Napa River, Calistoga											×	×					
Conn Creek											×	×					

SYSTEMATIC DISCUSSION OF SPECIES.

The proportional measurements[a] recorded in the following pages are expressed in hundredths of the length from the tip of the snout to the base of the caudal fin.

The tables are intended to record something of the degree of differentiation which has arisen between closely allied forms. They will also serve to indicate the individual variation of certain characters as well as it may be shown by the examination of a small series of specimens.

1. **Entosphenus tridentatus** (Gairdner).

Young examples of this species were occasionally found in quiet pools, buried several inches in the soft sand and mud. Specimens were taken in the Willamette, Nestucca, Umpqua, Coquille, Rogue, Klamath, Eel, Garcia, Big, Russian, and Napa rivers.

[a] The method of measuring here adopted is explained in Snyder, Bulletin U. S. Bureau Fisheries, vol. XXVII, 1907, page 79.

2. Acipenser medirostris Ayres.

A large specimen from the Klamath River, near its mouth, was examined. The plates were located as follows: Mid-ventral row, 3 in front of anal, 2 behind; ventro-lateral row, 9; lateral row, 27; dorsal row, 11 in front of dorsal fin, 3 behind.

3. Catostomus rimiculus Gilbert & Snyder.

Practically no difference has been discovered between examples of this species taken in the Klamath and Rogue rivers. Examples from the Rogue appear to have the dorsal and ventral fins inserted somewhat more posteriorly than those of the Klamath. The difference is slight, not constant, and may be due in part to unequal shrinkage of specimens in preservation.

The largest specimen seen measured 410 mm. in length.

Klamath and Rogue rivers.

MEASUREMENTS OF CATOSTOMUS RIMICULUS.

Klamath River basin.

	Klamath River near mouth.					Shasta River near Yreka.						
Length of body ... mm.	234	242	252	275	301	334	262	250	225	228	223	212
Length head	.235	.24	.235	.23	.235	.225	.235	.23	.225	.24	.22	.23
Depth body	.20	.185	.20	.19	.195	.20	.19	.22	.24	.225	.215	.20
Depth caudal peduncle	.095	.095	.097	.095	.095	.085	.092	.095	.095	.092	.095	.095
Length caudal peduncle	.165	.155	.17	.17	.16	.16	.175	.165	.175	.18	.18	.185
Length snout	.11	.115	.105	.105	.11	.105	.12	.115	.11	.12	.105	.11
Diameter eye	.035	.035	.035	.03	.03	.03	.03	.035	.035	.032	.035	.035
Interorbital width	.095	.095	.095	.085	.095	.095	.10	.10	.095	.105	.10	.092
Depth head	.15	.155	.155	.15	.15	.16	.162	.16	.15	.175	.15	.15
Snout to dorsal	.485	.495	.495	.465	.485	.48	.50	.49	.485	.50	.48	.48
Snout to ventral	.57	.59	.565	.555	.57	.55	.555	.565	.56	.56	.575	.56
Length base of dorsal	.15	.145	.135	.145	.135	.14	.15	.14	.14	.135	.13	.15
Length base of anal	.07	.075	.08	.085	.09	.072	.075	.075	.075	.072	.08	.075
Height dorsal	.16	.155	.145	.15	.14	.142	.14	.145	.15	.15	.15	.15
Height anal	.185	.185	.18	.185	.18	.182	.17	.17	.17	.18	.17	.19
Length pectoral	.21	.195	.205	.20	.20	.195	.185	.17	.185	.20	.175	.19
Length ventral	.145	.145	.14	.145	.14	.14	.14	.145	.14	.135	.145	.145
Length caudal	.225	.23	.22	.205	.21	.20	.205	.20	.205	.21	.19	.21
Dorsal rays	12	11	11	11	11	11	12	11	11	11	10	12
Anal rays	7	7	7	7	7	7	7	7	6	7	7	7
Scales lateral line	91	89	91	89	88	86	88	85	89	85	93	89
Scales above lateral line	17	19	18	18	17	16	17	19	16	16	18	18
Scales before dorsal	45	47	44	40	44	38	42	39	39	40	39	44

Rogue River basin.

	South Fork Illinois River.					Bear Creek, Ashland, Oreg.				
Length of body ... mm.	247	266	281	285	296	77	86	90	101	135
Length head	.26	.26	.24	.235	.24	.25	.245	.24	.24	.225
Depth body	.22	.205	.21	.205	.20	.21	.21	.20	.21	.215
Depth caudal peduncle	.095	.095	.09	.095	.097	.09	.09	.09	.09	.095
Length caudal peduncle	.16	.15	.165	.16	.165	.17	.17	.165	.16	.17
Length snout	.125	.135	.12	.12	.125	.11	.12	.11	.12	.10
Diameter eye	.035	.035	.033	.033	.03	.05	.045	.045	.04	.04
Interorbital width	.095	.10	.095	.09	.095	.09	.09	.09	.095	.09
Depth head	.17	.175	.16	.15	.17	.16	.16	.16	.16	.16
Snout to dorsal	.51	.525	.505	.50	.51	.52	.52	.51	.50	.50
Snout to ventral	.585	.61	.575	.57	.56	.58	.59	.58	.58	.56
Length base of dorsal	.14	.13	.13	.135	.13	.14	.14	.14	.16	.14
Length base of anal	.075	.07	.08	.08	.08	.075	.07	.07	.07	.07
Height dorsal	.15	.16	.15	.14	.135	.17	.17	.16	.17	.15
Height anal	.18	.195	.185	.185	.18	.17	.16	.165	.18	.17
Length pectoral	.19	.20	.185	.175	.185	.21	.21	.21	.21	.19
Length ventral	.14	.15	.135	.14	.135	.15	.16	.16	.16	.14
Length caudal	.225	.215	.205	.21	.205	.24	.23	.22	.22	.22
Dorsal rays	11	12	10	11	11	11	11	11	12	11
Anal rays	7	7	7	7	7	7	7	6	7	7
Scales lateral line	87	89	90	89	89	81	81	87	84	81
Scales above lateral line	16	16	17	15	17	15	15	16	16	16
Scales before dorsal	42	43	41	42	45	38	38	40	39	41

SCALE COUNTS IN CATOSTOMUS RIMICULUS.

	Klamath River near mouth.	Shasta River near Yreka.	Illinois River.	Rogue River near mouth.	Total.
In lateral line:	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
81 scales	1				1
83 scales	1				1
84 scales	1	1	1	1	4
85 scales		2			2
86 scales		1	1		2
87 scales	3		5	1	9
88 scales	3	1	2	1	7
89 scales		1	1		2
90 scales	1	4	1	1	7
91 scales	2		1	1	4
92 scales		1			1
93 scales	1	1			2
Above lateral line:					
15 scales			1		1
16 scales		2	3	3	8
17 scales	3	5	6	1	15
18 scales	2	1	1	1	5
19 scales	6	4			10
20 scales	1	1	1		3
21 scales	1				1
Before dorsal:					
37 scales		1			1
38 scales		2			2
39 scales		2	4		6
40 scales	1	5		2	8
41 scales			3		3
42 scales	1		2	1	4
43 scales	1	1	1		3
44 scales	2		1		3
45 scales	4	1	1	1	7
46 scales	2			1	3
51 scales	1				1
52 scales	1				1

4. Catostomus occidentalis Ayres.

Specimens from the Russian River appear to differ in no way from those of Napa River or of the Sacramento basin.

Russian and Napa river basins.

MEASUREMENTS OF CATOSTOMUS OCCIDENTALIS.

Sacramento River basin.

	Yuba River.			Goose Lake.							
Length of body mm.	273	262	237	267	258	255	238	222	232	223	255
Length head	.24	.238	.23	.228	.225	.235	.225	.232	.228	.225	.23
Depth body	.19	.18	.19	.20	.195	.20	.206	.21	.22	.225	.21
Depth caudal peduncle	.085	.088	.082	.09	.085	.085	.08	.09	.085	.085	.085
Length caudal peduncle	.15	.165	.155	.165	.16	.16	.172	.18	.17	.17	.165
Length snout	.13	.12	.115	.105	.10	.105	.11	.105	.11	.11	.10
Width lower lip	.065	.06	.062	.065	.05	.05	.042	.05	.05	.05	.05
Diameter eye	.04	.04	.042	.035	.04	.038	.038	.04	.04	.05	.035
Interorbital width	.098	.10	.095	.10	.10	.11	.10	.105	.10	.095	.11
Depth head	.15	.15	.16	.17	.165	.17	.162	.17	.175	.165	.17
Snout to occiput	.212	.205	.195	.195	.19	.195	.185	.20	.185	.20	.20
Snout to dorsal	.52	.495	.49	.47	.485	.49	.48	.51	.50	.49	.48
Snout to ventral	.59	.58	.58	.565	.58	.585	.55	.58	.58	.54	.54
Length base of dorsal	.175	.155	.16	.16	.17	.165	.16	.15	.155	.165	.18
Length base of anal	.085	.08	.08	.08	.085	.072	.08	.075	.08	.085	.08
Height dorsal	.162	.165	.18	.16	.15	.162	.16	.158	.165	.17	.17
Height anal	.20	.18	.175	.19	.185	.18	.23	.185	.19	.205	.23
Length pectoral	.20	.19	.19	.20	.18	.195	.21	.21	.205	.22	.205
Length ventral	.162	.152	.165	.15	.142	.15	.155	.15	.155	.16	.16
Length caudal	.223	.212	.23	.21	.21	.225	.22	.222	.225	.222	.225
Dorsal rays	13	12	12	12	12	12	11	11	11	11	12
Scales lateral line	69	62	64	72	63	67	71	65	71	69	64
Scales above lateral line	15	16	15	17	16	15	15	17	16	16	15
Scales before dorsal	34	37	32	37	34	31	35	37	38	38	32

MEASUREMENTS OF CATOSTOMUS OCCIDENTALIS—Continued.

Sacramento River basin—Continued.

	Cache Creek, Yolo County, Cal.							
Length of body.....mm..	212	[illegible]	[illegible]	[illegible]	193	172	[illegible]	[illegible]
Length head	.23	[illegible]	[illegible]	[illegible]	.24	.24	.245	.24
Depth body	[illegible]	.21	.22	.225	.215	.23	.225	.225
Depth caudal peduncle	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Length caudal peduncle	[illegible]	[illegible]	.175	[illegible]	[illegible]	[illegible]	[illegible]	.15
Length snout	.11	[illegible]	.11	.105	.11	.115	.11	.12
Width lower lip	[illegible]	[illegible]	[illegible]	.04	.05	.05	.05	.052
Diameter eye	.045	[illegible]	.045	.04	.045	.05	.045	.04
Interorbital width	.095	.10	.10	.10	.11	.105	.10	.10
Depth head	.17	.17	.165	.165	.165	.17	.175	.175
Snout to occiput	.195	.23	[illegible]	[illegible]	.21	.21	.205	.21
Snout to dorsal	.49	.52	[illegible]	.51	[illegible]	.52	[illegible]	[illegible]
Snout to ventral	.575	.575	[illegible]	.58	.57	.58	.54	[illegible]
Length base of dorsal	[illegible]	[illegible]	.185	.172	.175	[illegible]	[illegible]	.17
Length base of anal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Height dorsal	.175	[illegible]	.165	.18	.18	.18	[illegible]	.18
Height anal	.175	.18	.17	.17	[illegible]	.18	.185	.18
Length pectoral	.195	.165	.185	[illegible]	[illegible]	.165	[illegible]	[illegible]
Length ventral	.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Length caudal	.255	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.25
Dorsal rays	12	12	14	13	12	12	12	14
Scales lateral line	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Scales above lateral line	17	[illegible]	[illegible]	[illegible]	[illegible]	14	15	[illegible]
Scales before dorsal	34	34	32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Russian River basin.

	Dry Creek near Healdsburg.									
Length of body.....mm..	79	95	100	119	151	155	177	[illegible]	[illegible]	211
Length head	.27	.26	.25	.26	.24	.25	.24	[illegible]	[illegible]	.245
Depth body	.215	.25	.23	.235	.23	.235	.24	[illegible]	.23	[illegible]
Depth caudal peduncle	.085	.08	.08	.08	.085	.08	.085	.083	.085	[illegible]
Length caudal peduncle	.14	.135	.15	.135	.14	.16	.15	.14	.135	.14
Length snout	.12	.12	.115	.12	.115	.125	.12	.11	.125	.12
Width lower lip	.05	.055	.042	.05	.045	.045	[illegible]	.05	.043	.045
Diameter eye	.055	.05	.05	.055	.05	.05	.045	.045	.045	.045
Interorbital width	.10	.10	.09	.10	.095	.09	.09	.095	.10	.10
Depth head	.175	.17	.18	.17	.17	.17	.165	.16	.165	.165
Snout to dorsal	.53	.525	.525	.53	.51	.52	.525	.52	.525	.52
Snout to ventral	.58	.575	.58	.60	.575	.59	.57	.575	.58	[illegible]
Length base of dorsal	.19	.18	.18	.18	.185	.175	.185	.19	.20	.175
Length base of anal	.08	.08	.075	.075	.09	.083	.085	.095	.085	.09
Height dorsal	.21	.19	.19	.20	.19	.185	.175	.175	.19	.175
Height anal	.18	.185	.175	.19	.17	.175	.175	.185	.21	.165
Length pectoral	.215	.21	.205	.215	.20	.20	.20	.195	.21	.165
Length ventral	.17	.17	.16	.16	.16	.16	.155	.145	.17	.15
Length caudal	.28	.25	.25	.26	.25	.24	.24	.24	.26	[illegible]
Dorsal rays	13	12	12	13	13	12	13	13	14	14
Scales lateral line	70	67	69	65	68	70	[illegible]	[illegible]	[illegible]	71
Scales above lateral line	15	13	15	14	15	15	15	15	15	15
Scales before dorsal	33	32	32	32	31	35	31	31	33	32

5. Catostomus humboldtianus, new species.

The affinities of this species are with *C. occidentalis* of the Sacramento and adjacent streams. It differs from *C. occidentalis* in having larger scales between the occiput and insertion of dorsal (28 to 33 rows against 30 to 36) and larger scales above the lateral line (11 to 14 rows between lateral line and middle of back near origin of dorsal, against 13 to 17). The mouth is larger than that of *C. occidentalis*, the papillose lips are broader, usually extend farther backward, and have larger papillæ. The eye is smaller and the pectorals are rounded instead of pointed. The differences exhibited by the mouth and eye will usually serve to distinguish the species at a glance. From *C. snyderi* of the Klamath basin it differs in having fewer scales in the lateral series (62 to 69 in the lateral line against 70 to 77) and in having a much larger mouth with markedly broader lips.

Distribution, Mad, Eel, and Bear rivers, Humboldt County, Cal.

Head 4 in length; depth 4.25; depth of caudal peduncle 2.75 in head; eye 8; snout 2.14; interorbital space 2.5; number of dorsal rays 12; anal rays 7; scales in lateral line 67; above lateral line 12; between lateral line and ventral fin 9; between occiput and dorsal 30.

Width of mouth contained about 4 times in length of head; upper lip with 6 or 7 rows of papillæ anterior to mouth, lower lip split nearly to border of mouth; one or two rows of papillæ between cleft and border of lip; distance between anterior border of upper lip and posterior border of lobe of lower lip 2.9 in head; inner border of lips smooth and hard; 3 rows of minute papillæ between inner border of upper lip and the valve. Interorbital area convex. Length of fontanelle about equal to diameter of orbit.

Origin of dorsal fin midway between tip of snout and base of caudal fin; height of longest dorsal ray somewhat greater than length of bas[illegible] the latter contained 6.6 times in the length. Height of anal 2.3 times length of its base, 5 in th[illegible] tip of fin when depressed just reaching base of lower caudal rays. Pectoral rays 18, the longe[illegible]ained 5.1 in the length. Origin of ventral below ninth dorsal ray, the fin when depressed not reaching anal opening, 6.75 in the length. Caudal 4.8 in the length.

The scales grow gradually larger porteriorly, those on caudal peduncle being about twice the width of the anterior ones.

Color dusky above, the scales with dark borders; dorsal, caudal, and upper side of pectorals dusky; ventrals and anal whitish. Occasional specimens are somewhat brassy, having whitish tubercles on lower part of caudal peduncle, on anal and lower half of caudal fin.

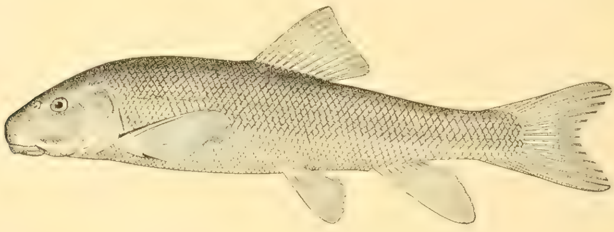


FIG. 1.—Catostomus humboldtianus, new species. Type.

Type, in U. S. National Museum, a specimen from the south fork of Eel River, near Garberville, Humboldt County, Cal. Cotype no. 9861, Stanford University.

No differences have been detected between specimens from Bear, Eel, and Mad rivers. *C. humboldtianus* appears to be a slightly differentiated form of *C. occidentalis*, resembling that species much more closely than *C. snyderi* of the Klamath. It is well to note in this connection that but little is known of *C. snyderi*, and a detailed and thorough examination of *C. occidentalis* is yet to be made.

Bear, Eel, and Mad rivers.

MEASUREMENTS OF CATOSTOMUS HUMBOLDTIANUS.

	Eel River.					Mad River.				
Length of body.....mm..	234	239	221	227	203	185	198	185	175	190
Length head	.25	.245	.24	.245	.24	.25	.26	.265	.25	.26
Depth body	.24	.235	.22	.24	.23	.23	.22	.215	.24	.23
Depth caudal peduncle	.095	.095	.09	.095	.095	.09	.09	.10	.10	.095
Length caudal peduncle	.175	.17	.165	.16	.16	.16	.16	.15	.168	.155
Length snout	.125	.115	.115	.13	.12	.13	.13	.135	.115	.135
Width lower lip	.055	.065	.055	.062	.062	.07	.067	.065	.055	.065
Diameter eye	.035	.035	.033	.035	.038	.04	.04	.04	.035	.04
Interorbital width	.11	.10	.098	.098	.105	.10	.098	.105	.10	.105
Depth head	.175	.175	.165	.17	.175	.18	.18	.175	.18	.18
Snout to occiput	.20	.21	.21	.215	.205	.225	.23	.225	.20	.24
Snout to dorsal	.515	.51	.51	.50	.505	.52	.53	.525	.505	.52
Snout to ventral	.575	.575	.60	.59	.58	.60	.59	.62	.625	.59
Length base of dorsal	.15	.14	.145	.153	.145	.15	.15	.145	.155	.165
Length base of anal	.085	.07	.063	.08	.065	.08	.072	.075	.07	.08
Height dorsal	.18	.165	.16	.17	.18	.165	.155	.155	.16	.16
Height anal	.20	.17	.172	.20	.19	.172	.18	.175	.18	.19
Length pectoral	.205	.19	.18	.20	.195	.205	.185	.18	.195	.18
Length ventral	.15	.14	.14	.15	.15	.15	.14	.145	.15	.14
Length caudal	.235	.21	.21	.215	.24	.22	.21	.22	.23	.225

Scale and Fin Characters of Catostomus humboldtianus from Mad, Eel, and Bear Rivers.

Mad River.				Eel River.				Bear River.			
Scales in lateral line.	Scales above lateral line.	Scales before dorsal fin.	Rays in dorsal fin.	Scales in lateral line.	Scales above lateral line.	Scales before dorsal fin.	Rays in dorsal fin.	Scales in lateral line.	Scales above lateral line.	Scales before dorsal fin.	Rays in dorsal fin.
65	13	33	12	67	13	32	12	64	12	29	11
65	12	28	12	65	12	31	12	63	12	28	12
65	13	31	12	62	13	31	12	64	13	28	12
62	14	29	12	67	13	30	12	64	13	30	11
65	13	28	12	64	13	31	12	63	12	28	12
63	13	28	11	68	13	31	12	66	13	31	12
69	13	31	12	68	13	30	12	62	13	28	12
65	13	33	12	66	13	30	12	64	14	31	12
65	14	31	12	67	13	30	13	70	13	30	12
65	12	31	12	69	14	33	12	63	14	30	12
65	13	32	12	67	14	33	12	64	13	30	12
65	13	30	11	68	12	33	12	63	13	29	12
66	14	32	12	67	11	30	11	63	13	28	12
68	13	31	12	66	13	29	12	62	12	29	12
69	13	31	12	66	12	28	12	63	12	29	12
67	11	29	11	67	13	28	11	67	13	30	12
67	13	32	12	66	12	29	12	62	12	29	11
64	12	28	12	62	12	29	12	63	13	29	12
65	12	29	11	64	12	27	12	64	13	29	12
65	12	28	12	65	13	31	12	60	12	29	12

Comparative Scale and Fin Characters of Catostomus occidentalis and Catostomus humboldtianus.

	C. occidentalis.	C. humboldtianus.
Having in series above lateral line—	*Specimens.*	*Specimens.*
11 scales	....	2
12 scales	....	20
13 scales	11	41
14 scales	24	7
15 scales	36	....
16 scales	25	....
17 scales	5	....
Having in series between occiput and dorsal fin—		
27 scales	....	1
28 scales	....	12
29 scales	3	14
30 scales	11	13
31 scales	12	16

	C. occidentalis.	C. humboldtianus.
Having in series between occiput and dorsal fin—(Continued).	*Specimens.*	*Specimens.*
32 scales	23	6
33 scales	15	6
34 scales	10	2
35 scales	12	
36 scales	13	
37 scales	1	
Showing in dorsal fin—		
11 rays	....	12
12 rays	52	55
13 rays	42	2
14 rays	5	....
15 rays	2	....

6. **Catostomus snyderi** Gilbert.

The coarse-scaled sucker of the Klamath appears to be a rare form, but few examples having been seen. One large individual was taken in the Klamath near its mouth.

The species seems to differ from *C. occidentalis* and *C. macrocheilus* in having a shorter and somewhat deeper head, a narrower mouth with smaller lips, a much deeper caudal peduncle, somewhat smaller scales and fewer dorsal rays.

Klamath River.

7. **Catostomus macrocheilus** Girard.

The coarse-scaled sucker of the Columbia River is so nearly like that of the Sacramento that its specific distinctness may be regarded with some doubt. It appears to differ from the Sacramento form in having slightly shorter fins, the pectorals being at the same time more rounded, and in usually having a smaller eye. The scales are alike in both forms, and the fin rays are equal in number.

C. macrocheilus occurs in the larger coastwise streams of Oregon north of the Rogue River. No characters have been detected which will serve to distinguish specimens taken in any of these rivers from those of the Columbia basin. The results of a comparison of a few specimens from each of several isolated basins are given in the appended tables.

In the larger streams individuals of this species often attain a length of 2 feet. They may sometimes be seen frequenting the deeper pools in great numbers. Large schools often follow the tide down the lower courses of the rivers, frequently venturing some distance into the brackish water. In Coos River 81 specimens, measuring from 250 to 420 millimeters long, were cut off from such a school without perceptibly reducing its size.

Drs. Evermann and Meek record the species from Tsiltcoos Lake and the Siuslaw River as *Catostomus tsiltcoosensis*.[a] A much larger series of specimens from both the coastal streams of Oregon and from the Willamette and lower Columbia than was accessible to these authors makes it appear that no differences exist between examples from the Siuslaw and Tsiltcoos rivers and the lower Columbia.

Willamette, Nehalem, Siuslaw, Umpqua, Coos, Coquille, Flores, and Sixes river basins.

MEASUREMENTS OF CATOSTOMUS MACROCHEILUS.

	Columbia River basin.													
	Willamette River, Junction City.									Willamette River near Corvallis.				
Length of body ....mm..	380	318	328	292	298	308	300	312	263	322	313	305	287	330
Length head	.245	.25	.24	.235	.245	.23	.245	.235	.23	.25	.255	.265	.247	.248
Depth body	.19	.20	.24	.21	.215	.22	.23	.20	.215	.23	.21	.22	.22	.21
Depth caudal peduncle	.073	.08	.08	.075	.075	.078	.082	.075	.075	.08	.078	.08	.08	.075
Length caudal peduncle	.16	.145	.17	.15	.165	.152	.16	.16	.16	.15	.175	.16	.16	.165
Length snout	.12	.13	.12	.11	.12	.11	.115	.12	115	.12	.115	12	.12	.115
Width lower lip	.065	.063	.048	.05	.055	.05	.05	.055	.04	.04	.045	.045	.047	.05
Diameter eye	.033	.035	.035	.033	.035	.033	.033	.033	.038	.035	.035	.03	.036	.035
Interorbital width	.098	.095	.11	.10	.10	.10	.105	.105	.10	.105	.105	.11	.10	.11
Depth head	.165	.175	.172	.165	.17	.165	.18	.165	.16	.165	.175	.17	.168	.172
Snout to occiput	.20	.23	.21	.20	.21	.185	.20	.195	.192	.205	.21	.20	.21	.195
Snout to dorsal	.50	.525	.51	.495	.495	.51	.52	.495	.49	.485	.49	.475	.505	.50
Snout to ventral	.565	.58	.55	.56	.575	.585	.58	.55	.56	.54	.57	.545	.565	.565
Length base of dorsal	.165	.17	.172	.175	.16	.165	.175	.175	.175	.19	.18	.20	.19	.18
Length base of anal	.08	.075	.08	.075	.08	.075	.085	.085	.08	.085	.08	.085	.085	.08
Height dorsal	.135	.145	.14	.148	.16	.145	.155	.135	.16	.145	.165	.15	.145	.145
Height anal	.185	.22	.172	.185	.19	.18	.175	.185	.17	.225	.19	.215	.20	.185
Length pectoral	.173	.195	.175	.20	.20	.195	.172	.19	.175	.182	.193	.185	.195	.177
Length ventral	.133	.14	.145	.145	.14	.145	.13	.142	.132	.14	.142	.145	.148	.138
Length caudal	.205	.23	.20	.22	.23	.205	.20	.21	.21	.207	.235	.225	.24	.225
Dorsal rays	14	14	31	14	14	14	14	15	13	14	14	15	15	15
Scales lateral line	67	68	65	68	75	72	72	75	76	73	72	68	66	77
Scales above lateral line	13	14	13	14	16	13	14	14	13	14	14	14	14	16
Scales before dorsal	36	35	35	36	36	36	35	36	38	36	35	33	34	38

	Columbia River basin—Continued.			Nehalem River basin.									
	Long Tom Creek.			Nehalem River, near mouth.									
Length of body ....mm..	148	175	215	425	303	183	156	156	146	142	185	178	188
Length head	.25	.25	.245	.26	.235	.232	.24	.237	.24	.25	.235	.245	.255
Depth caudal peduncle	.07	.075	.08	.085	.08	.082	.075	.08	.08	.08	.08	.08	.08
Width lower lip	.045	.055	.05	.058	.055	.038	.043	.045	.045	.048	.045	.048	.05
Diameter eye	.045	.04	.04	.035	.035	.038	.043	.042	.04	.043	.04	.04	.04
Snout to occiput	.212	.21	.19	.23	.192	.192	.21	.21	.215	.215	.215	.22	.21
Snout to dorsal	.51	.52	.51	.49	.49	.48	.49	.49	.49	.51	.51	.51	.515
Snout to ventral	.59	.58	.535	.53	.57	.572	.56	.565	.57	.58	.56	.555	.57
Height dorsal	.17	.17	.17	.125	.135	.16	.16	.165	.16	.175	.16	.16	.162
Height anal	.18	.18	.20	.17	.20	.175	.15	.16	.175	.165	.17	.165	.17
Length pectoral	.19	.19	.20	185	.185	.19	175	.185	19	.182	.18	.18	.19
Length ventral	16	.15	.16	135	.145	.14	.145	.14	.145	.14	.14	.135	.142
Length caudal	.24	.24	.24	.21	.20	.22	.22	.215	.23	.235	.222	.225	238
Dorsal rays	14	14	14	13	13	13	13	13	.13	13	14	13	13
Scales lateral line	70	68	74	68	67	70	65	65	73	71	70	66	68
Scales above lateral line	15	15	15	15	15	15	15	15	14	14	16	13	14
Scales before dorsal	35	32	35	35	34	32	32	33	31	30	34	34	30

[a] *Catostomus tsiltcoosensis* Evermann & Meek, Bulletin U. S. Fish Commission, vol. XVII, 1898, p. 68.

MEASUREMENTS OF CATOSTOMUS MACROCHEILUS—Continued.

	Siuslaw River basin.		Umpqua River basin. Callapooia Creek.								
Length of body.........mm..	400	330	226	305	289	293	251	240	229	220	166
Length head	.27	.25	.24	.24	.235	.252	.24	.235	.24	.23	.235
Depth caudal peduncle	.095	.09	.09	.085	.08	.092	.09	.08	.085	.086	.085
Width lower lip	.065	.058	.06	.065	.053	.058	.05	.05	.055	[illegible]	[illegible]
Diameter eye	.035	.035	.04	.038	.038	.049	.04	.04	.04	.042	.042
Snout to occiput	.225	.215	.205	.21	.21	.21	.20	.215	.21	.195	.215
Snout to dorsal	.53	.515	.515	.512	.52	.50	.51	.52	.51	.515	.55
Snout to ventral	.58	.58	.59	.555	.54	.58	.57	.58	.58	.60	.575
Height dorsal	.14	.132	.15	.145	.142	.14	.16	.162	.15	.15	.155
Height anal	.18	.185	.17	.185	.18	.18	.18	.19	.175	.18	.19
Length pectoral	.172	.185	.172	.17	.182	.18	.19	.195	.175	.19	.205
Length ventral	.132	.14	.145	.13	.14	.135	.15	.155	.14	.155	.15
Length caudal	.205	.205	.225	.225	.215	.21	.21	.23	.22	.215	.25
Dorsal rays	13	12	14	14	13	13	12	13	12	14	14
Scales lateral line	65	71	67	65	68	69	66	65	65	67	68
Scales above lateral line	14	14	16	15	14	17	16	15	14	14	14
Scales before dorsal	36	35	35	33	33	36	39	35	37	38	34

	Umpqua River basin—Continued. Elk Creek, near Drain.								Coos River basin. South Fork Coos River.					
Length of body.........mm..	170	134	123	126	121	124	116	118	325	370	353	282	294	330
Length head	.25	.25	.25	.235	.245	.245	.245	.25	.222	.222	.23	.242	.225	.225
Depth caudal peduncle	.08	.09	.085	.08	.08	.085	.08	.085	.09	.092	.092	.09	.092	.09
Width lower lip	.055	.05	.05	.045	.05	.048	.055	.045	.05	.053	.05	.045	.052	.045
Diameter eye	.042	.05	.05	.05	.05	.05	.05	.05	.032	.03	.032	.035	.037	.032
Snout to occiput	.23	.22	.23	.21	.22	.22	.22	.215	.195	.195	.19	.20	.19	.195
Snout to dorsal	.515	.51	.52	.49	.50	.51	.51	.52	.468	.48	.49	.495	.48	.495
Snout to ventral	.58	.59	.60	.59	.60	.59	.595	.59	.552	.562	.59	.57	.55	.562
Height dorsal	.162	.18	.175	.18	.182	.17	.18	.19	.135	.125	.135	.142	.14	.135
Height anal	.18	.19	.175	.17	.18	.185	.17	.175	.175	.175	.18	.192	.22	.17
Length pectoral	.20	.20	.195	.185	.20	.195	.19	.195	.162	.165	.18	.162	.172	.165
Length ventral	.15	.15	.15	.145	.15	.15	.15	.15	.132	.125	.14	.145	.145	.135
Length caudal	.25	.26	.265	.26	.27	.26	.265	.265	.198	.18	.195	.21	.21	.195
Dorsal rays	13	13	14	13	13	13	12	13	12	12	12	12	13	13
Scales lateral line	67	67	66	70	70	65	72	65	67	69	68	70	71	73
Scales above lateral line	14	15	15	14	14	14	15	16	14	14	13	14	12	14
Scales before dorsal	36	38	39	39	37	38	39	38	36	33	36	34	35	35

	Coos River basin—Continued. South Fork Coos River—Continued.				Coquille River basin. Coquille River near Myrtle Point.										
Length of body.........mm..	300	243	268	220	252	194	200	218	197	199	200	183	186	230	260
Length head	.23	.232	.24	.22	.25	.245	.25	.245	.26	.25	.245	.255	.25	.235	.265
Depth caudal peduncle	.092	.092	.09	.09	.09	.085	.083	.085	.085	.09	.085	.085	.085	.092	.09
Width lower lip	.052	.044	.052	.04	.05	.05	.05	.055	.052	.058	.05	.05	.05	.048	.055
Diameter eye	.032	.038	.035	.037	.037	.038	.04	.04	.042	.042	.038	.042	.042	.038	.035
Snout to occiput	.195	.195	.195	.195	.225	.21	.225	.205	.23	.218	.22	.22	.22	.20	.232
Snout to dorsal	.48	.50	.512	.495	.51	.495	.52	.51	.52	.50	.52	.495	.51	.51	.52
Snout to ventral	.58	.562	.59	.59	.565	.568	.58	.57	.59	.58	.58	.58	.595	.58	.59
Height dorsal	.16	.14	.14	.14	.15	.16	.16	.155	.16	.165	.17	.16	.15	.165	.175
Height anal	.18	.165	.172	.169	.20	.175	.185	.17	.185	.185	.185	.18	.175	.185	.18
Length pectoral	.18	.165	.178	.169	.19	.21	.185	.185	.20	.20	.185	.20	.18	.178	.175
Length ventral	.14	.135	.138	.135	.15	.14	.145	.135	.145	.158	.15	.15	.14	.155	.145
Length caudal	.192	.20	.215	.195	.22	.22	.225	.215	.22	.22	.225	.24	.22	.19	.225
Dorsal rays	12	13	12	12	12	13	13	12	12	12	13	13	12	11	11
Scales lateral line	72	69	73	75	72	69	74	72	72	70	70	75	75	69	68
Scales above lateral line	14	15	13	15	13	13	14	15	14	14	14	15	14	14	13
Scales before dorsal	37	33	35	35	33	33	34	37	35	33	34	31	31	37	31

Measurements of Catostomus macrocheilus—Continued.

	Flores River basin.												Sixes River basin.	
	Flores River near mouth.													
Length of body........mm..	259	295	292	326	273	255	296	305	320	292	260	270	330	365
Length head	.232	.24	.23	.225	.23	.225	.25	.233	.25	.24	.235	.24	.245	.25
Depth caudal peduncle	.09	.09	.088	.085	.09	.09	.09	.09	.09	.085	.095	.095	.10	.095
Width lower lip	.05	.045	.042	.043	.048	.04	.058	.05	.055	.05	.05	.048	.047	.05
Diameter eye	.035	.035	.036	.03	.038	.035	.032	.035	.035	.035	.038	.038	.032	.032
Snout to occiput	.185	.19	.20	.205	.19	.195	.21	.19	.222	.205	.21	.20	.215	.22
Snout to dorsal	.48	.51	.50	.475	.49	.485	.525	.485	.495	.51	.50	.49	.53	.53
Snout to ventral	.565	.585	.54	.54	.555	.56	.575	.575	.56	.58	.57	.56	.572	.57
Height dorsal	.16	.155	.155	.142	.15	.155	.16	.158	.145	.145	.155	.15	.16	.145
Height anal	.205	.168	.22	.162	.22	.21	.175	.18	.18	.165	.215	.22	.195	.18
Length pectoral	.19	.19	.19	.172	.18	.195	.19	.185	.185	.18	.195	.195	.185	.18
Length ventral	.132	.135	.145	.128	.142	.132	.135	.135	.135	.132	.14	.142	.15	.15
Length caudal	.22	.223	.235	.20	.212	.23	.23	.232	.21	.205	.225	.24	.225	.195
Dorsal rays	11	12	13	12	13	13	11	12	12	12	12	12	12	12
Scales lateral line	72	68	69	70	69	68	67	73	69	73	71	69	71	71
Scales above lateral line	14	14	13	13	14	14	14	13	14	13	13	14	13	14
Scales before dorsal	31	33	33	32	34	33	38	33	33	35	35	38	35	33

Scales and Dorsal Rays of Catostomus macrocheilus and Catostomus occidentalis.

Catostomus macrocheilus.

	Willamette River.	Nehalem River.	Siuslaw River.	Umpqua River.	Coos River.	Coquille River.	Flores Creek.	Sixes River.	Total.
	Specimens.	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
In lateral line:									
65 scales	3	3	2	6					14
66 scales	1	1		3					5
67 scales	3			6	3	1	1		14
68 scales	6	2		7	1	1	2		19
69 scales		1		5	2	1	4	1	14
70 scales		4	1	3	1	2	1	1	13
71 scales		1	1		2	3	1	2	10
72 scales	6		1	1	1	4	1		14
73 scales	1	1			2		2		6
74 scales						2			2
75 scales	2	1			1	2			6
76 scales	1								1
Above lateral line:									
12 scales	1					1			2
13 scales	8	4	1	4	5	5	5	3	35
14 scales	13	5	4	14	4	7	7	1	55
15 scales		4		9	2	3			18
16 scales	1	1		3	1				6
17 scales				1					1
Before dorsal:									
30 scales	2	5	1						8
31 scales	1	1		1		4	1		8
32 scales	1	5	1	4		1	1		13
33 scales	3	1		4	4	4	5	2	23
34 scales	1	2		5	1	2	1		12
35 scales	6			4	5	3	2	2	22
36 scales	7		2	3	2				14
37 scales				4	1	2			7
38 scales	2			5			2		9
39 scales				1					1
Dorsal rays:									
11 scales						2	2		4
12 scales			1	3	9	8	7	4	32
13 scales	6	11	3	15	3	6	3		47
14 scales	12	3	1	12	1				29
15 scales	5			1					6

SCALES AND DORSAL RAYS OF CATOSTOMUS MACROCHEILUS AND CATOSTOMUS OCCIDENTALIS—Continued.

Catostomus occidentalis.

	Stony Creek, Cal.	Cache Creek, Cal.	Putah Creek, Cal.	Russian River, Cal.	Total.
In lateral line:	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
62 scales				1	1
63 scales		1	2	1	4
64 scales	1	1	1	5	8
65 scales	4			2	6
66 scales	1	4	1	4	10
67 scales	1	4	1	7	13
68 scales	1	4	1	6	12
69 scales		3		6	9
70 scales	3	3	2		8
71 scales		1	1		2
72 scales	1	1	2	4	8
73 scales			1		1
74 scales	1			1	2
75 scales	1				1
Above lateral line:					
13 scales	4	1		4	9
14 scales	3	8	2	9	22
15 scales	5	4	6	10	25
16 scales	1	7	4	12	24
17 scales	1	2		1	4
Before dorsal:					
29 scales				3	3
30 scales	3	2	1	4	10
31 scales	2	3		4	9
32 scales	1	4	5	8	18
33 scales	1	4	1	4	10
34 scales	3	2	1	4	10
35 scales	1	4	1	4	10
36 scales	2	3	3	5	13
Dorsal rays:					
12 scales	7	15	6	17	45
13 scales	7	5	6	16	34
14 scales				3	3
15 scales				1	1

8. **Acrocheilus alutaceus** Agassiz & Pickering.

Not found in the streams south of the Columbia.
Willamette and tributaries.

9. **Lavinia exilicauda** Baird & Girard.

Occurs in Napa River, but has not been taken in the Russian River or in any streams to the northward.

10. **Mylopharodon conocephalus** (Baird & Girard).

This species is found in the Russian River, where it reaches its northern limit of distribution. It was not taken in Napa River.

The dorsal fin has 8 rays; the anal 8, rarely 9. There are from 71 to 81 scales in the lateral line.
Russian River and tributaries.

MEASUREMENTS OF MYLOPHARODON CONOCEPHALUS FROM THE RUSSIAN RIVER.

Length of body . . . mm	[illegible]	131	141	149	158	[illegible]	[illegible]	[illegible]	150	172
Length head	[illegible]	.27	.26	.26	.26	.26	.26	.27	.27	.26
Depth body	[illegible]	[illegible]	.215	.21	[illegible]	.23	.22	.225	[illegible]	[illegible]
Snout to dorsal	[illegible]	[illegible]	.56	.56	[illegible]	.56	.57	.57	.57	.56
Snout to ventral	[illegible]	[illegible]	.53	.53	[illegible]	.54	.525	.55	.54	.53
Depth caudal peduncle	[illegible]	[illegible]	.09	.09	[illegible]	.09	.09	.09	.09	.09
Length caudal peduncle	[illegible]	[illegible]	.17	.17	.18	[illegible]	[illegible]	[illegible]	.18	[illegible]
Length snout	[illegible]	[illegible]	.085	.09	[illegible]	.09	.085	.09	.09	.09
Length maxillary	[illegible]	[illegible]	.085	.09	[illegible]	.09	.09	.09	.09	.09
Diameter eye	[illegible]	[illegible]	.05	.05	[illegible]	.045	.045	.045	.05	.05
Interorbital width	[illegible]	.10	.10	.10	[illegible]	.10	.10	.10	.10	.095
Depth head	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.155	.15
Length base of dorsal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.12	.115	.115	.115	.125
Height dorsal	[illegible]	[illegible]	.18	.19	[illegible]	.19	.185	.19	[illegible]	.18
Length base of anal	[illegible]	[illegible]	.11	.10	[illegible]	[illegible]	[illegible]	[illegible]	.10	.10
Height anal	[illegible]	[illegible]	.15	.16	[illegible]	.155	.16	.16	.16	.15
Length pectoral	[illegible]	[illegible]	.165	.18	[illegible]	.17	.175	.175	.17	.17
Length ventral	[illegible]	[illegible]	.15	.16	[illegible]	.15	.16	.16	.15	.15
Length caudal	[illegible]	[illegible]	.25	.275	[illegible]	.25	.255	.27	.26	.25
Dorsal rays	8	8	9	8	8	9	8	8	8	8
Anal rays	8	8	8	8	8	8	8	8	8	8
Scales lateral line	[illegible]	[illegible]	78	75	[illegible]	81	[illegible]	[illegible]	79	79
Scales above lateral line	[illegible]	[illegible]	19	19	[illegible]	[illegible]	[illegible]	[illegible]	18	18

11. Mylocheilus lateralis Agassiz & Pickering.

This is the *Mylocheilus caurinus* of recent authors and is not to be confused with *Leuciscus caurinus* Richardson.

The species does not inhabit the coastwise streams south of the Columbia River.

Willamette basin.

12. Ptychocheilus grandis (Ayres).

No difference has been observed between specimens of this species from the Russian River and from the Sacramento.

Russian and Napa rivers.

SCALES AND DORSAL RAYS OF PTYCHOCHEILUS GRANDIS.

	Specimens examined.	Dorsal rays.	Scales above lateral line.		Specimens examined.	Dorsal rays.	Scales above lateral line.
Putah Creek (Sacramento)	3	8	[illegible]	Dry Creek near Healdsburg (Russian River)			
		8	[illegible]		22	8	
	5	8	[illegible]		2	9	
Cache Creek (Sacramento)	3	8	[illegible]		9	....	13
	4	8	[illegible]		[illegible]		14
Cottonwood Creek (Sacramento)	5	8	[illegible]		1	....	15
	1	8	[illegible]				
Warm Springs Creek (Russian River)	5	8	[illegible]				
	1	8	[illegible]				

13. Ptychocheilus oregonensis (Richardson).

Willamette and tributaries.

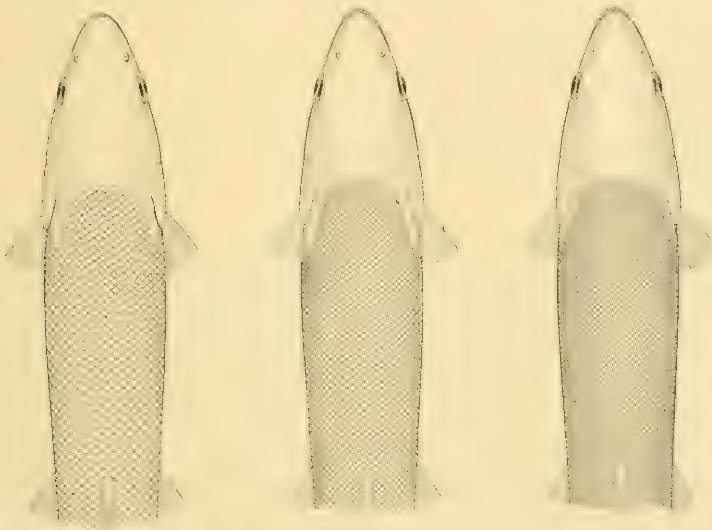
14. Ptychocheilus umpquæ, new species.

Ptychocheilus oregonensis is represented in the Siuslaw and Umpqua rivers by a well marked form here described as new. It differs from *P. oregonensis* in having smaller scales, especially in the region posterior to the occiput, where they are minute and densely crowded.

Head exclusive of opercular flap, 3.8 in length to base of caudal; depth 5.2; snout 3 in head; eye 6; interorbital space 4; maxillary 2.75; dorsal 9; anal 8; scales in lateral line 75; in series above lateral line 21; between occiput and dorsal 65.

The form of the body is like that common to *P. oregonensis* and *P. grandis*, long and rather slender, the depth about one-fourth greater than the width; depth of caudal peduncle equal to length of

maxillary. Head conical, the snout rounded in outline when viewed from above, pointed when seen from the side. Jaws about equal, the lower included by the upper; maxillary projecting to a vertical through anterior edge of pupil; interorbital space low, slightly concave; nostrils located anterior to eye a distance equal to diameter of pupil; membranous flap of opercle equal in width to pupil. Gill-rakers on first arch minute, only 5 or 6 developed near angle of arch. Teeth 2, 5–4, 2, without grinding surface, the upper teeth (those nearest angle of arch) close set, the space between them not greater than half the diameter of first tooth, the two lower ones usually more widely spaced; the second tooth from below largest and longest; upper teeth hooked, the hooks growing gradually less pronounced on the second and third, scarcely discernible on the lowest. Alimentary canal with 2 folds, its length about equal to distance between snout and base of caudal. Posterior portion of air bladder 1.5 times as long as the anterior part. Peritoneum silvery, stippled with black. Vertebræ 45.



a b c

FIG. 2.—(*a*) Ptychocheilus grandis, (*b*) P. oregonensis, and (*c*) P. umpquæ, showing characteristic difference in size of scales which distinguishes the species.

Scales very small on median portion of back anterior to the dorsal, and on breast and throat; minute and densely crowded anteriorly.

Base of dorsal lying entirely between verticals through anterior edge of ventral and anal; posterior edge of fin straight, the rays graduated in length so that when depressed the first and last extend an equal distance posteriorly, reaching a vertical through middle of base of anal. Anal slightly rounded posteriorly, the anterior rays reaching a little beyond the posterior ones when depressed. Ventrals rounded, reaching midway between anus and base of anal fin. Pectorals rounded, their tips reaching two-thirds the distance between axil and base of ventral.

Color silvery, often more or less brassy; the upper parts dusky.

Type no. 61577, U. S. National Museum, Callapooia Creek, Oakland, Oreg., length, 238 mm. Cotype no. 9862, Stanford University.

This species is found in the Umpqua and its tributaries. It also occurs in the Siuslaw River and in the small lakes near the coast between the latter river and the Umpqua. No characters are evident which will separate the Umpqua basin specimens from those of the Siuslaw.

The following table shows in some detail the chief differences between *P. oregonensis* and *P. umpquæ* as demonstrated by an examination of 98 specimens.

DIFFERENCES IN SIZE OF SCALES OF PTYCHOCHEILUS OREGONENSIS AND PTYCHOCHEILUS UMPQUÆ.

Ptychocheilus oregonensis.

	Willamette River.	Columbia River, Astoria.	Skookumchuck River.	Payette River.	Silvies River, Oreg.	Total.
In lateral line:	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
67 scales			1	1		2
68 scales	2	1	1		2	6
69 scales	4		1		4	9
70 scales	2			2	3	7
71 scales	3			2	1	6
72 scales	1	1	1			3
73 scales	1	1			1	3
74 scales			1		3	4
75 scales	1		1	1	1	4
Before dorsal:						
46 scales			1	1	1	3
47 scales	1			3	1	5
48 scales	2		3		1	6
49 scales	2		1		2	5
50 scales	2				4	6
51 scales		1			2	3
52 scales					1	1
53 scales	3	2	1		2	8
54 scales	2			1	1	4
55 scales	1					1
56 scales	1			1		2
Above lateral line:						
16 scales	1	1	2	1		5
17 scales	7		1	1	3	12
18 scales	5	1	3	3	5	17
19 scales	1			1	5	7
20 scales		1			2	3

Ptychocheilus umpquæ.

	S. Umpqua River.	Callapooia Creek.	Siuslaw River.	Tsiltcoos River.	Total.
In lateral line:	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
73 scales			1		1
74 scales		1	2		3
75 scales		4			4
76 scales	1	2	1		4
77 scales	2	3	1		6
78 scales	3	1		1	5
79 scales	3		1	1	5
80 scales	4	2	2		8
81 scales	5	1		1	7
82 scales	3		1		4
83 scales	3		2		5
84 scales	1				1
85 scales	1				1
Before dorsal:					
55 scales			2		2
56 scales	2			1	3
58 scales	2		1		3
59 scales	4		1		5
60 scales	3	1		1	5
61 scales	3	1	2		6
62 scales	4	3	2	1	10
63 scales	2	3	1		6
64 scales		1			1
65 scales	3	1	1		5
66 scales		1			1
67 scales	2	3	1		6
68 scales	1				1
Above lateral line:					
19 scales			1		1
20 scales	3		3	1	7
21 scales	10	4	2	1	17
22 scales	13	7	4		24
23 scales		2	1	1	4
24 scales		1			1

MEASUREMENTS OF PTYCHOCHEILUS UMPQUÆ FROM CALLAPOOIA CREEK, OAKLAND, OREG.

Length of body.....mm..	192	198	176	176	177	175	203	192	192	188
Length head	.27	.275	.265	.28	.28	.265	.275	.275	.275	.275
Depth body	.20	.22	.21	.22	.21	.20	.215	.20	.21	.21
Snout to dorsal	.59	.585	.575	.59	.575	.575	.575	.57	.57	.58
Snout to ventral	.55	.56	.565	.57	.565	.55	.57	.55	.565	.55
Length of snout	.095	.095	.095	.10	.10	.09	.10	.10	.10	.10
Length maxillary	.11	.105	.11	.115	.115	.105	.115	.105	.11	.11
Diameter eye	.05	.045	.05	.05	.05	.045	.045	.05	.045	.05
Interorbital width	.075	.075	.07	.08	.075	.07	.07	.07	.075	.07
Height dorsal	.16	.17	.16	.17	.155	.155	.155	....	.16	.17
Height anal	.15	.165	.15	.15	.145	.15	.145	.145	.145	.16
Length pectoral	.20	.20	.19	.165	.16	.175	.18	.19	.16	.195
Length ventral	.15	.15	.14	.135	.13	.135	.15	.15	.13	.15
Length caudal	.24	.245	.24	.23	.23	.24	.23	.23	.23	.24
Dorsal rays	9	9	9	9	9	9	9	9	9	9
Anal rays	8	8	8	8	8	8	8	8	8	8
Scales lateral line	75	76	80	75	75	77	78	76	75	77
Scales before dorsal	65	67	63	60	62	64	62	67	60	66
Scales above lateral line	21	22	23	21	23	22	22	21	21	22

15. **Leuciscus caurinus** Richardson.

The *Mylocheilus caurinus* of recent authors is the species described by Agassiz and Pickering as *Mylocheilus lateralis*[a], and should not be confused with *Leuciscus caurinus*[b] of Richardson.

A specimen of *Leuciscus caurinus* taken in the Willamette River near Corvallis is here described.

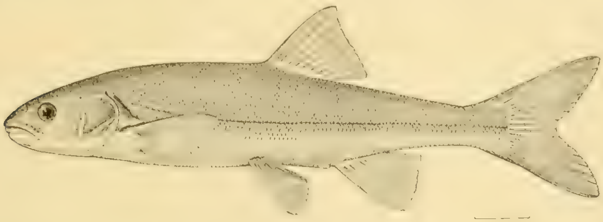


FIG. 3.—Leuciscus caurinus Richardson.

Head 4 in length to base of caudal; depth 4.6; depth caudal peduncle 3 in head; length snout 2.9; maxillary 3.1; diameter eye 5.6; width interorbital space 2.9; dorsal rays 10; anal 9; scales in lateral line 86.

Body elongate, the width contained about 1.5 times in the depth; head long, the snout prominent; mouth large, end of maxillary reaching a vertical passing midway between anterior edge of orbit and pupil; upper lip without foramen; lower jaw included, its edge being posterior to tip of snout, a distance equal to three-fourths the diameter of pupil; maxillary without barbel. Distance between nostril and eye equal to half the diameter of eye; eye located nearer tip of snout than edge of opercle, a distance equal to its diameter. Gillrakers on first arch 9 or 10, short, pointed. Pharyngeal teeth in two series, 2+4 on the right arch, 1+5 on the left; the lesser teeth slender and round, their tips curved away from the others; greater teeth considerably flattened, hooked at their tips, with a narrow though distinct grinding surface which is more pronounced on the middle teeth than on the outer ones. Peritoneum dusky. Exposed edges of scales semicircular; scales of breast and throat minute, those on back anterior to dorsal fin small, becoming minute and closely crowded on the nape; scales in series above lateral line 21, between dorsal and occiput about 50; lateral line complete, decurved in the region above pectoral fin; origin of dorsal fin midway between anterior edge of pupil and base of caudal, second fully developed ray longest, the last ray reaching slightly beyond it when the fin is depressed; free edge of fin slightly concave; origin of anal close behind base of last dorsal ray; first and last rays reaching

[a] Agassiz, L., American Journal Science & Arts, vol. XIX, 1855, p. 231.

[b] Richardson, John, Fauna Boreali-Americana, vol. III, 1836, p. 304.

an equal distance posteriorly when fin is depressed; posterior edge of fin slightly concave; caudal deeply notched; origin of ventrals about a pupil's diameter in advance of dorsal; tips of fins just reaching anal opening; pectorals obtusely pointed. Color plain; dusky above, light below. Length about 290 mm.

Willamette River.

16. Leuciscus bicolor (Girard).

One specimen was taken in the Klamath River near the mouth.

17. Leuciscus balteatus (Richardson).

Among the coastwise streams of Oregon this species has been taken in the Umpqua, Siuslaw, Takenitch, and Tsiltcoos rivers. It probably does not occur south of the Umpqua, nor in any of the streams between the Siuslaw and the Columbia.

Specimens of this form from the Siuslaw River were lately described by Dr. Evermann and Dr. Meek[a] under the name *Leuciscus siuslawi*. They were said to differ from *L. balteatus* in having smaller anal and dorsal fins, a more slender body, smaller and more slender head, longer and more pointed snout, and fewer anal rays. In a large series of examples from the Siuslaw, Tsiltcoos, Umpqua, Willamette, and Columbia rivers, these distinctions disappear entirely, and the *Leuciscus* from the isolated coastal streams of Oregon does not appear to differ in any way from that of the Columbia. It is to be noted, however, that no western Oregon specimens, whether from the Columbia or neighboring basins have been seen in which the anal fin rays numbered more than 16. It will be of interest in this connection to compare the following table of counts of fin rays with a similar one published by Dr. Gilbert and Dr. Evermann.[b]

Willamette, Siuslaw, Tsiltcoos, Takenitch, and Umpqua basins.

MEASUREMENTS OF LEUCISCUS BALTEATUS FROM FOUR RIVER BASINS.

	Umpqua River, Callapooia Creek, Oakland.					Takenitch Creek, near mouth.				
Length body .... mm..	100	97	88	101	76	92	94	93	96	96
Depth body	.28	.26	.25	.265	.25	.29	.27	.28	.25	.25
Length head	.255	.24	.26	.25	.26	.25	.25	.255	.25	.245
Length snout	.08	.08	.08	.085	.08	.08	.085	.08	.085	.08
Height dorsal	.175	.18	.18	.19	.20	.18	.185	.18	.19	.175
Height anal	.18	.17	.185	.20	.20	.19	.19	.195	.17	.18
	Siuslaw River, Lake Creek.					**Columbia River, Umatilla River, Pendleton.**				
Length body .... mm..	92	110	84	84	89	92	78	78	77	70
Depth body	.25	.26	.27	.26	.26	.275	.26	.265	.27	.28
Length head	.255	.25	.25	.25	.245	.25	.25	.23	.25	.25
Length snout	.08	.08	.08	.08	.08	.08	.08	.075	.08	.075
Height dorsal	.18	.18	.20	.17	.175	.18	.19	.17	.20	.20
Height anal	.18	.175	.19	.17	.175	.18	.18	.18	.18	.19

[a] *Leuciscus siuslawi* Evermann & Meek, Bulletin U. S. Fish Commission, vol. XVII, 1897, p. 72.

[b] Gilbert, C. H., & Evermann, B. W., Bulletin U. S. Fish Commission, vol. XIV, 1894, p. 196.

ANAL FIN RAYS OF LEUCISCUS BALTEATUS FROM STREAMS OF WESTERN OREGON.

Locality.	11 rays.	12 rays.	13 rays.	14 rays.	15 rays.	16 rays.
Umpqua basin:						
South Umpqua River, Roseburg	....	....	....	24	16	2
South Umpqua River, Canyonville	....	....	25	28	12	....
North Umpqua River, Winchester	....	....	2	4	....	....
Elk Creek, Drain		3	18	25		
Cow Creek, Douglas County		34	36	3		
Callapooia Creek, Oakland			8	18	10	1
Deer Creek, near Roseburg			9	8		
Takenitch Creek		1	6	1		
Tsiltcoos River		6	12	2		
Junction Lake and Deadwood Creek		8				
Willamette basin (Columbia):						
Willamette River, Corvallis			5	10	6	2
Willamette River, Eugene	2		8	7	1	2
Long Tom Creek		1	7	3		
The Lakes, Albany		1	1	7		
Coast Fork, Cottage Grove		1	6	4		
Row River, near Cottage Grove		2	3	2	2	

18. Rutilus symmetricus (Baird & Girard).

A minnow of this type occurs in the Navarro, Gualala, Russian, and Napa rivers. Specimens from the Russian and Napa rivers are alike in all respects, and they in turn agree closely with representatives from the streams tributary to San Francisco Bay. In a majority of cases the dorsal fin has 9 rays and the anal 8. The snout is rather pointed, the caudal peduncle slender and the fins long, the whole body being trim and well proportioned. Examples from the Navarro and Gualala rivers are distinguished from these by having generally 8 rays in the dorsal fin, a more robust body with a deeper caudal peduncle, and a more rounded and shortened snout. The fins are also shorter and somewhat less acute. While examples from the Navarro and Gualala rivers thus agree in differing from specimens taken in the neighboring basins, individuals from each of these streams bear a distinctive local stamp by which they may be recognized without difficulty, the Navarro examples having mostly one more ray in the anal fin and larger scales in the series above the lateral line. It has been shown that individuals from the partly isolated rivers tributary to San Francisco Bay[a] are alike in all points and that these are scarcely to be distinguished in any particular from individuals from the Napa and Russian rivers. Hence it appears that there are 3 well-differentiated forms of *Rutilus* in this somewhat restricted region, each of which occupies a distinct hydrographic basin or series of contiguous basins. When, however, the field is broadened and specimens from distant parts of the Sacramento and San Joaquin basins are brought together, similar variations of a local nature are found to occur, but whether any geographical significance may be attached to these can not be known until more extensive observations have been made. One of these local forms (*Rutilus symmetricus*) from Drew Creek, a tributary of Goose Lake, appears almost exactly to parallel the Gualala form, while another from Mariposa Creek, a branch of the San Joaquin, seems to be somewhat intermediate between the Russian River and Gualala varieties.

The males of *R. symmetricus* when in nuptial dress have the upper part of the head and body covered with tubercles. There is a patch of bright orange red at angle of mouth, on edge of preopercle, upper edge of opercle, and on bases of the paired fins. The sides of head and lower parts of body have a translucent brassy color.

The species does not occur to the northward of the Navarro River.

Navarro, Gualala, Russian, and Napa rivers.

[a] *Rutilus symmetricus*, Snyder, Appendix to Report Commissioner of Fisheries for 1904, p. 332.

DORSAL AND ANAL RAYS OF RUTILUS SYMMETRICUS FROM VARIOUS BASINS.

Locality.	8 dorsal rays.	9 dorsal rays.	6 anal rays.	7 anal rays.	8 anal rays.	9 anal rays.
	Specimens.	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
Navarro River	72			3	68	1
Gualala River	80		1	70	9	
Russian River	22	49		5	66	
Napa River		97			95	2
Putah Creek		14			11	3
Berryessa Creek	6	12			18	
Pope Creek	19	5		1	23	
Kelsey Creek	12	10		3	19	
Mariposa Creek	18			18		
Tule River	2	14		1	15	
Fresno River	6	4		3	7	
Merced River	16	1		11	6	
Arroyo Hondo Creek		26		1	25	
Coyote Creek	1	23			24	
San Francisquito Creek	1	32			32	1

MEASUREMENTS OF RUTILUS SYMMETRICUS.

Russian River near Healdsburg, Cal.

Length of body ... mm	62	72	73	75	75	77	78	79	79	86
Length head	.27	.27	.26	.28	.28	.26	.27	.265	.26	.27
Depth body	.27	.26	.25	.26	.28	.25	.26	.265	.27	.25
Snout to dorsal	.56	.58	.57	.57	.58	.58	.58	.56	.57	.57
Snout to ventral	.51	.52	.53	.52	.525	.52	.51	.51	.52	.52
Depth caudal peduncle	.10	.11	.095	.11	.10	.10	.105	.095	.10	.105
Length caudal peduncle	.205	.19	.195	.20	.20	.18	.18	.17	.19	.18
Length snout	.08	.08	.08	.09	.09	.08	.09	.08	.08	.075
Length maxillary	.08	.08	.08	.08	.09	.08	.08	.08	.08	.08
Diameter eye	.06	.06	.06	.06	.06	.06	.06	.06	.06	.055
Interorbital width	.09	.09	.09	.09	.10	.09	.10	.09	.09	.09
Depth head	.19	.19	.175	.19	.19	.18	.19	.18	.1	.18
Length base of dorsal	.15	.14	.135	.13	.145	.16	.14	.135	.135	.14
Height dorsal	.20	.19	.20	.21	.20	.19	.185	.19	.20	.19
Length base of anal	.11	.11	.095	.10	.11	.11	.11	.11	.11	.11
Height anal	.19	.17	.18	.20	.18	.165	.18	.16	.16	.17
Length pectoral	.20	.19	.20	.25	.19	.18	.18	.19	.19	.20
Length ventral	.15	.14	.15	.17	.14	.14	14	14	14	.15
Length caudal	.27	.27	.28	.27	.28	.27	.27	.25	.27	.26
Dorsal rays	10	9	9	9	9	9	9	9	9	9
Anal rays	8	8	8	8	8	8	8	8	8	8
Scales in lateral line	59	59	53	55	58	51	51	54	55	57
Scales above lateral line	12	11	12	12	13	12	13	12	13	12

Napa River, Calistoga, Cal.

Length of body ... mm	60	61	73	74	76	77	78	78	86	94
Length head	.27	.29	.26	.26	.26	.26	.26	.255	.28	.25
Depth body	.28	.26	.26	.27	.28	.28	.29	.26	.28	.26
Snout to dorsal	.58	.575	.57	.585	.56	.56	.58	.57	.58	.57
Snout to ventral	.52	.53	.51	.52	.50	.52	.52	.52	.53	.52
Depth caudal peduncle	.11	.10	.10	.10	.11	.10	.10	.10	.095	.095
Length caudal peduncle	.19	.175	.18	.17	.17	.17	.175	.175	.17	.175
Length snout	.08	.08	.09	.08	.08	.08	.08	.085	.09	.08
Length maxillary	.08	.08	.08	.08	.08	.08	.08	.075	.08	.07
Diameter eye	.07	.07	.065	.06	.06	.06	.065	.06	.06	.055
Interorbital width	.09	.09	.08	.08	.09	.09	.09	.085	.09	.08
Depth head	.19	.19	.17	.18	.19	.18	.18	.18	.20	.18
Length base of dorsal	.15	.145	.135	.14	.15	.14	.14	.14	.14	.14
Height dorsal	.20	.21	.19	.20	.19	.19	.20	.20	.20	.18
Length base of anal	.11	.11	.11	.11	.12	.11	.11	.115	.10	.11
Height anal	.19	.19	.16	.18	.17	.17	.18	.16	.17	.16
Length pectoral	.19	.21	.20	.19	.17	.19	.19	.17	.17	.18
Length ventral	.14	.15	.14	.14	.14	.14	.15	.13	.15	.14
Length caudal	.28	.28	.25	.27	.27	.24	.29	.26	.28	.25
Dorsal rays	9	9	9	9	9	9	9	9	9	9
Anal rays	8	8	8	8	8	8	8	8	8	8
Scales in lateral line	56	57	56	56	56	59	53	55	55	56
Scales above lateral line	13	13	14	14	13	14	13	13	13	13

MEASUREMENTS OF RUTILUS SYMMETRICUS—Continued.

Wheatfield Fork, Gualala River, Cal.

Length of body.....mm..	44	61	64	65	70	71	73	74	76	81
Length head	.29	.26	.27	.275	.27	.27	.28	.27	.27	.27
Depth body	.25	.235	.24	.23	.24	.25	.23	.25	.25	.25
Snout to dorsal	.57	.56	.57	.57	.57	.56	.56	.57	.58	.55
Snout to ventral	.52	.50	.52	.53	.51	.52	.52	.52	.52	.52
Depth caudal peduncle	.115	.115	.105	.12	.12	.12	.115	.105	.11	.11
Length caudal peduncle	.20	.19	.19	.20	.20	.19	.19	.17	.18	.20
Length snout	.09	.085	.09	.09	.085	.08	.09	.09	.09	.085
Length maxillary	.09	.08	.08	.08	.08	.075	.08	.085	.08	.075
Diameter eye	.06	.055	.06	.06	.06	.055	.055	.055	.055	.05
Interorbital width	.08	.09	.09	.09	.085	.09	.09	.09	.095	.095
Depth head	.19	.18	.18	.19	.185	.175	.18	.18	.18	.18
Length base of dorsal	.125	.12	.115	.115	.12	.115	.12	.125	.12	.12
Height dorsal	.20	.19	.19	.19	.19	.17	.18	....	.17	.17
Length base of anal	.09	.09	.08	.09	.085	.085	.08	.10	.09	.085
Height anal	.17	.17	.17	.17	.165	.16	.15	.15	.15	.155
Length pectoral	.19	.215	.22	.22	.22	.20	.22	.175	.18	.18
Length ventral	.14	.14	.15	.14	.15	.14	.14	.14	.14	.13
Length caudal	.25	.24	.24	.24	.23	.21	.215	.23	.22	.23
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	8	7	7	7	7	7	7	7	8
Scales in lateral line	54	59	55	55	57	55	57	59	56	59
Scales above lateral line	14	14	15	14	14	14	15	15	16	15

Navarro River near Philo, Cal.

Length of body.....mm..	59	65	67	72	73	73	76	77	80	80
Length head	.28	.28	.27	.27	.27	.26	.28	.27	.27	.27
Depth body	.26	.26	.27	.28	.27	.25	.27	.26	.25	.26
Snout to dorsal	.58	.59	.57	.57	.56	.57	.56	.58	.56	.58
Snout to ventral	.52	.53	.53	.55	.52	.51	.51	.51	.52	.52
Depth caudal peduncle	.11	.12	.11	.11	.12	.11	.11	.12	.12	.11
Length caudal peduncle	.20	.19	.19	.20	.20	.20	.21	.19	.18	.19
Length snout	.08	.09	.09	.09	.085	.08	.09	.085	.09	.09
Length maxillary	.08	.09	.085	.08	.08	.08	.08	.08	.08	.08
Diameter eye	.06	.06	.06	.06	.06	.055	.06	.06	.055	.055
Interorbital width	.09	.085	.09	.09	.09	.09	.09	.09	.09	.08
Depth head	.19	.19	.19	.20	.185	.18	.19	.18	.19	.18
Length base of dorsal	.11	.12	.12	.115	.13	.12	.115	.12	.13	.12
Height dorsal	.18	.185	.18	.18	.19	.18	.17	.19	.18	.13
Length base of anal	.08	.095	.11	.095	.09	.095	.09	.095	.10	.10
Height anal	.16	.16	.15	.16	.16	.16	.15	.18	.17	.145
Length pectoral	.17	.19	.17	.17	.22	.19	.18	.21	.20	.17
Length ventral	.12	.135	.13	.13	.14	.13	.125	.16	.15	.13
Length caudal	.22	.23	.23	.25	.24	.24	.23	.26	.24	.23
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	8	8	8	8	7	8	8	8	8	8
Scales in lateral line	56	52	51	56	56	57	53	58	52	59
Scales above lateral line	11	12	13	13	13	13	14	13	12	12

Mariposa Creek, Mariposa, Cal.

Length of body.....mm..	83	79	83	76	70
Length head	.27	.26	.27	.26	.26
Depth body	.25	.23	.24	.22	.24
Snout to dorsal	.58	.58	.57	.565	.55
Snout to ventral	.50	.53	.54	.53	.51
Depth caudal peduncle	.12	.11	.12	.11	.11
Length caudal peduncle	.22	.25	.26	.22	.23
Length snout	.09	.09	.095	.085	.08
Length maxillary	.09	.08	.095	.085	.08
Diameter eye	.055	.06	.055	.055	.06
Interorbital width	.09	.09	.095	.09	.09
Depth head	.20	.19	.19	.19	.18
Length base of dorsal	.13	.12	.125	.12	.125
Height dorsal	.17	.16	.17	.17	.18
Length base of anal	.10	.12	.09	.095	.10
Height anal	.17	.15	.16	.16	.17
Length pectoral	.20	.21	.20	.19	.22
Length ventral	.16	.16	.15	.14	.17
Length caudal	.25	.28	.25	.25	.26
Dorsal rays	8	8	8	8	8
Anal rays	7	7	7	7	7
Scales in lateral line	54	58	59	56	52
Scales above lateral line	12	14	12	13	14

19. Rutilus bicolor (Girard).

Several specimens from the Klamath River, near its mouth, were lighter in color but differed in no other way from examples taken in the Shasta River, near Yreka and Montague.

Klamath River.

20. Rhinichthys dulcis (Girard).

Apparently rare. One specimen was taken in the Willamette at Eugene and another near Corvallis.

21. Rhinichthys evermanni, new species.

This species is characterized by a narrow head, long snout, slender caudal peduncle, elongate fins, the anal being somewhat falcate, and by having 9 rays in the dorsal. From *Rhinichthys dulcis* (Girard) it may be distinguished by its slender caudal peduncle, elongate fins, more prominent snout, larger scales, and more numerous dorsal rays.

Head 3.8 in length to base of caudal fin; depth 4.25; eye 5.7 in head; snout 2.1; interorbital space 4; depth of caudal peduncle 3.25; dorsal rays 9; anal 7; scales in lateral line 61; above lateral line 12; between occiput and origin of dorsal 34.

Deepest part of body at origin of ventrals, the width about 1.5 the depth. Head long, the snout obtusely pointed; eye located slightly posterior to middle of head; interorbital space convex. Mouth inferior, the snout projecting a distance equal to diameter of eye; lips very thick, the upper with a broad

FIG. 4.—Rhinichthys evermanni, new species. Type.

phrenum; maxillary with a barbel attached to its posterior edge, equal in length to diameter of pupil, the barbel inconspicuous on account of the broad, rather pendulous lip; width of mouth equal to width of space between the eyes. Gillrakers minute, 4 or 5 on first arch. Teeth 2-4, 4-2, long and slender, without grinding surface; the two posterior or upper teeth hooked, the others rather blunt. Peritoneum silvery; intestinal canal short, its length about equal to distance between snout and base of caudal.

Lateral line slightly decurved near its origin, nearly straight throughout the remainder of its length.

Origin of dorsal midway between pupil and base of caudal; free edge of fin slightly concave; when depressed the tips of first dorsal rays fall a little short of the last. Origin of anal below last ray of dorsal; when depressed the first rays fall considerably beyond tips of the last ones; in some individuals the first rays are more elongate, the free edge of the fin being deeply concave. Ventrals reaching base of third anal ray. Dorsal and ventrals located a little farther posteriorly than is usual in *R. dulcis*. Pectorals and ventrals sharply rounded. Caudal deeply notched, the lobes pointed.

Color in alcohol brownish, very finely stippled with black especially on edges of scales; an indefinite dark band extending from near tip of snout to eye; a similar indistinct band along side of body. Young examples have a conspicuous dark band about as wide as pupil extending forward from eye, and a somewhat broader, less prominent band running backward from opercle, broadening on posterior end of caudal peduncle, contracting on base of caudal, where it ends in a small, distinct spot.

Type no. 61572, U. S. National Museum, from South Umpqua River, Roseburg, Oreg. Length 107 mm. Collected by Frank Cramer and K. Otaki. Cotype no. 9861, Stanford University. Specimens were taken only in the type locality.

In his field notes Mr. Cramer mentions that the species was taken in shallow, rapid water, the river being high and muddy at the time. Other collectors have not succeeded in finding it.

Of 107 specimens of *R. dulcis* from 13 localities in the Columbia basin, all have 8 rays in the dorsal, except two which have 9. The number of scales in the lateral line varies from about 65 to 75. Measurements of *R. evermanni* and also of *R. dulcis* are appended.

Named for Dr. Barton Warren Evermann.

No form closely related to this species is known.

MEASUREMENTS OF RHINICHTHYS EVERMANNI FROM SOUTH UMPQUA RIVER, ROSEBURG, OREG.

Length of body.....mm..	39	39	41	60	64	65	78	86
Length head	.29	.29	.29	.28	.27	.27	.26	.26
Depth body	.20	.20	.18	.22	.23	.23	.23	.22
Depth caudal peduncle	.08	.09	.09	.085	.09	.08	.08	.08
Length caudal peduncle	.22	.20	.20	.20	.20	.20	.20	.20
Length snout	.12	.12	.12	.12	.12	.12	.12	.115
Length maxillary	.085	.085	.085	.08	.085	.08	.08	.08
Diameter eye	.07	.075	.06	.06	.06	.05	.05	.05
Interorbital width	.07	.075	.06	.06	.06	.055	.06	.06
Depth head	.16	.15	.15	.15	.15	.15	.15	.15
Snout to dorsal	.56	.55	.58	.57	.58	.57	.55	.58
Snout to ventral	.51	.51	.52	.52	.52	.51	.51	.52
Length base of dorsal	.12	.14	.15	.15	.15	.16	.15	.14
Length base of anal	.08	.11	.10	.10	.11	.12	.11	.095
Height dorsal	.22	.22	.21	.22	.21	.21	.22	.19
Height anal	.21	.21	.20	.21	.20	.21	.20	.21
Length pectoral	.24	.24	.22	.23	.22	.22	.22	.21
Length ventral	.18	.17	.18	.19	.18	.18	.17	.17
Length caudal	.25	.25	.25	.28	.26	.26	.27	.25
Dorsal rays	9	9	9	9	9	9	9	9
Anal rays	7	7	7	7	7	7	7	7
Scales lateral line	57	58	58	59	58	58	59	59
Scales above lateral line	13	13	13	14	13	13	13	14

MEASUREMENTS OF RHINICHTHYS DULCIS FROM ROSS FORK, POCATELLO, IDAHO.

Length of body.....mm..	85	89	90	63	60
Length head	.25	.26	.25	.25	.25
Snout to dorsal	.53	.54	.54	.55	.53
Snout to ventral	.48	.48	.50	.51	.48
Depth caudal peduncle	.12	.10	.12	.12	.12
Length snout	.11	.11	.11	.10	.10
Height anal	.165	.17	.15	.16	.17
Length pectoral	.19	.20	.20	.19	.21

22. Agosia nubila (Girard).

Examples of this species from the Yaquina, Siuslaw, and Coquille rivers appear to agree in having the barbels very small or frequently absent from one or both sides, while those from the Umpqua and Willamette have them always present and well developed. In large males the pectoral fins are often very long, while small tubercles are present on the head and upper parts of body.

The species was not found in the streams south of the Coquille.

Willamette, Nestucca, Yaquina, Alsea, Siuslaw, Umpqua, Coos, and Coquille rivers.

SCALE COUNTS IN AGOSIA NUBILA.

Scales in lateral series.	Willamette River, Corvallis.	Clear Creek, Oregon City.	Coast Fork, Cottage Grove.	Cow Creek, Douglas County.	Deer Creek, Roseburg.	Nestucca River.	Little Elk.	Lake Creek.	Coquille River.
	Specimens.	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
49		2	1						
50	1	2	3						
51		3	5						
52			5	2					
53	1		3	2	3				1
54	1		1	5	1				1
55	1			4		1			5
56	1			4	5				6
57				6		2			4
58				6	2	2	2		5
59				4	2	2	5		6
60				2	1	1	3		2
61				6	1		4		3
62				7	1	1	6	2	2
63				2			5		1
64				1		1	1	1	3
65				1		1	3	1	
67							1		
68							2		
69							1		
70							1		

23. **Agosia klamathensis** Evermann & Meek.

The above name is here retained for the *Agosia* of the Klamath basin, although this form is scarcely to be distinguished from the *Agosia nubila carringtoni* [a] of the upper Columbia.

Klamath River.

SCALE COUNTS IN AGOSIA KLAMATHENSIS.

Scales in lateral line.	Klamath River near mouth.	Shasta River near Montague.	Shasta River near Yreka.	Pickayune Lake, Trinity River.	Lost River near Klamath Falls.
	Specimens.	*Specimens.*	*Specimens.*	*Specimens.*	*Specimens.*
60		1	2		
61		1			
62		1	2		
63			2		
64			3	1	
65		2		2	
66		2	2	1	
67		3	3	1	
68		5	3	3	1
69		2	2	2	3
70		2	1	2	4
71		1	1		3
72				3	1
73		1		2	3
74		2			8
75		2		1	9
76	1	1			5
77	1			1	2
78	2				4
79	1				4
80	2				4
81	1				1

24. **Agosia falcata** Eigenmann & Eigenmann.

Specimens of this species were collected in the Willamette basin. None was found in the coastwise streams of Oregon.

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[a] Gilbert & Evermann, Investigations Columbia River Basin, Bulletin U. S. Fish Commission, vol. XIV, 1894, p. 191-193. Evermann & Meek, Salmon Investigations Columbia River Basin in 1896, ibid., vol. XVII, 1897, p. 74. Gilbert, Fishes of the Klamath Basin, ibid., vol. XVII, 1897, p. 9. Snyder, Relationships of Fish Fauna of Lakes of Southeastern Oregon, Bulletin Bureau of Fisheries, vol. XXVII, 1907, p. 98.

25. Hybopsis crameri, new species.

This species, which is apparently very different from any other in the genus, is distinguished by having the teeth in 2 rows, the grinding surface being at the same time well developed, and in possessing a markedly deep and compressed body with a relatively slender caudal peduncle. It is the only species[a] known to occur west of the Rocky Mountains. It has been found in the Willamette and Umpqua rivers.

Head 4 in length, depth 3.4, depth of caudal peduncle 2.5 in head, dorsal 8, anal 7, scales in lateral line 37, above lateral line 7, between occiput and dorsal 16.

Body notably deep and compressed, the caudal peduncle slender; width of body contained 2.5 times in the depth. Dorsal contour evenly curved and gradually rising from occiput to origin of dorsal, from which point it rapidly falls along base of fin, then curves more evenly and gently to base of caudal; profile concave over eye, the snout blunt; ventral outline evenly rounded from throat to end of anal base. Eye round, located in anterior half of head; interorbital space convex, its width contained 2.5 times in head; mouth oblique; jaws equal; premaxillary protractile, its length equal to diameter of orbit, reaching posteriorly to or slightly beyond edge of orbit; a minute barbel on the lower posterior edge. Pseudobranchiæ present; gillrakers very short and blunt, some of them mere knobs, 5 on

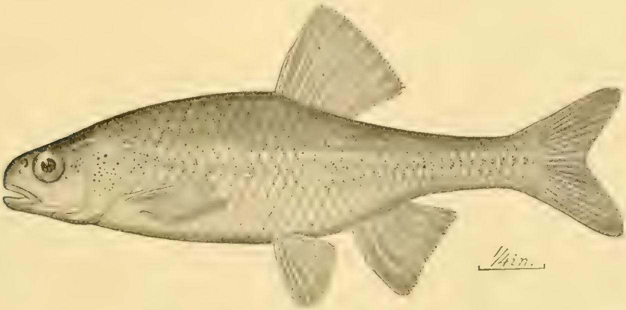

FIG. 5.—Hybopsis crameri, new species. Type.

first arch. Teeth rather slender, in 2 rows; 4 in the major row, slightly hooked and with a narrow grinding surface; 1 in the minor row. Alimentary canal short, coiled like the letter S. Peritoneum silvery, sparsely stippled with black in the dorsal region.

Scales large and regular. Lateral line complete, decurved on 3 scales near its origin, then running nearly straight alongside of body to base of caudal.

Origin of dorsal fin midway between anterior edge of orbit and base of caudal; longest ray contained about 4.25 in the length. Origin of anal below base of last dorsal ray; height of fin contained

[a] Günther described a species of *Hybopsis* (*Ceratichthys cumingii* Günther, Catalogue fishes of British Museum, vol. VII, p. 177), the types of which are said to be from California. Besides minor differences it is unlike *H. crameri* in having 10 dorsal and 9 anal rays, finer scales, and deeper body. The following description of Dr. Günther's types was made by Mr. Edwin Chapin Starks while studying in the British Museum:

2 specimens, 2.75 and 2.5 in. long.

Head 4–4.1 in length; depth 4.75; depth of caudal peduncle 2.5 in head; dorsal rays 10; anal 10; scales in lateral line 44 (tubes 42); above lateral line 6.5; between occiput and dorsal 20–22.

Body rather elongate, the caudal peduncle comparatively deep. Posterior edge of eye in middle of head; width of interorbital space contained 3 times in head; mouth oblique; jaws equal; premaxillary protractile, its length a little greater than diameter of orbit, reaching posteriorly to or slightly beyond edge of orbit.

Scales small; lateral line complete, decurved on 4 or 5 scales near its origin, then wavy or irregular along side of body to base of caudal.

Origin of dorsal fin midway between anterior edge of orbit and base of caudal; the longest ray contained about 5.33 times in the length. Origin of anal a little behind base of last dorsal ray; height of fin 6 in the length. Pectorals a little longer than ventrals, 5 in the length. Caudal deeply forked, 4.25 in the length.

A fairly conspicuous dark band extending along the side posteriorly to base of caudal; upper parts of body uniform light dusky; a narrow, median dusky band extending from occiput to dorsal fin.

5.3 in the length. Ventrals inserted directly below or slightly anterior to origin of dorsal, their tips when depressed extending to base of second anal ray. Pectorals a little longer than ventrals, 4.5 in the length. Caudal deeply forked, 4 in the length.

According to Mr. Cramer's notes the color in life is pale olive overlaid with silver; a fairly conspicuous silver band extending along the side to base of caudal; upper parts of body speckled with black, the specks grouped here and there in clusters; scales on dorsal half of body narrowly edged with dusky; top of head dark, a narrow, median dusky band extending from occiput to dorsal fin. In spirits the color changes to light brown, the silver partly disappears, and an inconspicuous dusky band is seen along the side, most evident posteriorly.

This description, except the life color, is of the type, no. 61574, U. S. National Museum, a specimen 65 mm. long from the Willamette River at Oregon City, Oreg., Messrs. Frank Cramer and K. Otaki, collectors. Cotype no. 9863, Stanford University. Named for its discoverer, Mr. Frank Cramer.

The barbel is sometimes absent from one or both sides. Among 35 specimens from "The Lakes," near Albany, Oreg., 3 are without barbels. There is also some individual variation in the color, the small spots on the sides sometimes forming in longitudinal lines. Besides the specks which are massed together to form rather distinct spots there are isolated ones of large size occurring most frequently below the lateral line. The appended table shows some variations of a local character, the anal fin being lower and the caudal shorter in the specimens from the Willamette basin. Short fin rays are not characteristic of individuals from the Willamette, however, as in 10 specimens from "The Lakes" the anal averages 0.2 and the caudal 0.3 of the length.

Willamette and Umpqua basins.

MEASUREMENTS OF HYBOPSIS CRAMERI.

Willamette River, Oregon City.

Length of body ......mm..	38	39	41	44	52	52	53	55	55	56
Length head	.24	.24	.24	.24	.26	.26	.26	.25	.25	.25
Depth body	.25	.25	.28	.30	.31	.29	.29	.31	.28	.32
Depth caudal peduncle	.09	.09	.09	.10	.09	.09	.09	.09	.09	.09
Length caudal peduncle	.25	.25	.23	.25	.24	.22	.23	.23	.24	.22
Length snout	.07	.065	.06	.07	.075	.065	.065	.07	.07	.065
Diameter eye	.08	.075	.07	.075	.07	.07	.065	.07	.065	.07
Interorbital width	.09	.095	.09	.09	.095	.08	.09	.09	.09	.09
Snout to dorsal	.55	.54	.54	.54	.55	.57	.55	.54	.55	.56
Snout to ventral	.48	.48	.48	.49	.51	.51	.52	.48	.51	.52
Length base of dorsal	.15	.15	.14	.15	.16	.14	.14	.15	.15	.16
Length base of anal	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Height dorsal	.23	.22	.21	.22	.23	.19	.20	.22	.21	.21
Height anal	.20	.17	.16	.19	.17	.17	.17	.19	.17	.17
Length pectoral	.19	.15	.16	.18	.18	.17	.17	.19	.17	.18
Length ventral	.18	.16	.15	.16	.16	.15	.16	.18	.16	.16
Length caudal	.25	.24	.24	.25	.23	.23	.25	.25	.24	.22
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	36	35	36	36	38	38	37	38	36	36
Scales above lateral line	6	6	6	6	6	6	6	6	6	6

Elk Creek near drain.

Length of body ......mm..	44	43	46	46	42	44	46	42	43	46
Length head	.26	.25	.25	.25	.25	.25	.26	.25	.26	.26
Depth body	.27	.27	.28	.27	.27	.28	.27	.27	.27	.28
Depth caudal peduncle	.09	.085	.085	.08	.09	.09	.08	.09	.09	.09
Length caudal peduncle	.24	.26	.23	.23	.23	.25	.23	.24	.24	.21
Length snout	.08	.075	.075	.07	.07	.08	.08	.08	.075	.075
Diameter eye	.08	.08	.075	.075	.07	.08	.08	.075	.07	.075
Interorbital width	.09	.085	.09	.085	.08	.08	.09	.09	.08	.09
Snout to dorsal	.56	.55	.57	.56	.56	.56	.56	.56	.56	.56
Snout to ventral	.51	.50	.52	.54	.52	.52	.54	.52	.52	.54
Length base of dorsal	.16	.16	.16	.17	.15	.16	.16	.16	.165	.16
Length base of anal	.12	.11	.12	.11	.11	.11	.10	.10	.12	.12
Height dorsal	.23	.22	.23	.23	.23	.23	.23	.22	.23	.22
Height anal	.20	.20	.21	.18	.21	.19	.18	.21	.21	.22
Length pectoral	.20	.20	.20	.19	.19	.20	.19	.21	.20	.21
Length ventral	.15	.18	.18	.17	.16	.18	.17	.18	.17	.18
Length caudal	.30	.29	.30	.30	.31	.29	.29	.31	.30	.30
Dorsal rays	8	8	8	8	8	8	8	8	8	8
Anal rays	7	7	7	7	7	7	7	7	7	7
Scales lateral line	36	36	36	36	38	37	36	38	37	35
Scales above lateral line	6	6	6	6	6	7	6	6	6	6

26. Coregonus williamsoni Girard.

Willamette River.

27. Oncorhynchus keta (Walbaum).

Occurs in all except the smallest streams between the Sacramento and Columbia rivers. The young of this salmon were apparently more abundant than those of any other.

28. Oncorhynchus tschawytscha (Walbaum).

To be found in the larger streams. Commonly reported to be growing less abundant.

Eel, Mad, Klamath, Rogue, Coquille, and Nehalem rivers.

29. Oncorhynchus kisutch (Walbaum).

Said to be commonly found in the larger streams. Specimens were taken in Takenitch Creek, Butte Creek at Eagle Point, Oregon, and in Redwood Creek, near Orick, Cal.

30. Salmo clarkii Richardson.

The trout observed by the writer in the coastal streams of Oregon and northern California are here referred to 2 species. From the Nehalem River southward to Redwood Creek in California a fine-scaled form was frequently taken, while from the Russian River northward, at least to the Tillamook, a large-scaled form was found to be abundant. The former, generally characterized by having from 140 to 170 scales in the lateral series, usually a red blotch on the inner side of the lower jaw, and teeth on the hyoid, are identified as *S. clarkii*. The latter, with from 110 to 145 scales, the lower jaw white and the hyoid without teeth, are called *S. irideus*. It is but fair to state that specimens which could hardly be referred to either species were sometimes taken in the streams north of Redwood Creek. For instance, in Hunters Creek, a tributary of the Klamath, specimens were collected in which the hyoid teeth were often absent and the throat red or not, without in any way coinciding with the number of scales, which varied from 120 to 150. The same conditions were found among specimens from the Coquille and other streams. In Nehalem River examples of typical *S. clarkii* were found. The throat was red, the scales numbered from 145 to 178, and the hyoid teeth were generally present.

No specimens of the form known as the steelhead, *S. rivularis*, were examined.

Trout are abundant in all the coastal streams, fairly swarming in those that have not been fished to excess. Their quality is unsurpassed, living as they do in clear, cool water, well supplied with food.

31. Salmo irideus Gibbons.

The trout found in the coastwise streams as far north as Redwood Creek are identified with this form. North of Redwood Creek examples brighter in color though apparently belonging to this form were frequently seen, together with others which could not be distinguished from the preceding species.

Trout were seen in every coastwise stream examined.

32. Columbia transmontana Eigenmann & Eigenmann.

Not found in the coastwise streams south of the Columbia.

Willamette River.

33. Gasterosteus cataphractus (Pallas).

A close scrutiny of about 2,000 specimens of this species [a] from the streams between the Sacramento and Columbia rivers appears to emphasize the seeming impossibility of recognizing within the group subspecies which may be defined by characters coordinate with geographical areas. The fully plated forms are apt to occur most often in or near salt water, while the less protected ones are usually found farther up the streams.

[a] For a discussion of the variations of the species see Jordan & Gilbert, Fishes of Bering Sea, in Report Fur-Seal Investigations 1896–1897, part 3, p. 443; also Rutter, Notes on freshwater fishes Pacific slope North America, Proceedings California Academy of Science, 2d ser., vol. VI, p. 245.

VARIATIONS IN GASTEROSTEUS CATAPHRACTUS.

Locality.	Specimens with—							
	4 to 6 plates.	7 or 8 plates.	9 or 10 plates.	10 to 12 plates, then an unprotected space followed by a low keel.	15 to 17 plates, then an unprotected space followed by a low keel.	Fully plated; posterior plates very small; keel low.	Fully plated; posterior plates large; keel high.	Small, young specimens 4 to 6 plates.
Conn Creek	200							
Napa River, Rutherford	25							
Napa River, Calistoga	165							
Dry Creek, Healdsburg	1							
Russian River, near Healdsburg	80							
Russian River, Ukiah	70							
Roberts Creek, Ukiah	8							
Wheatfield Fork, Gualala River	20							
Junction Wheatfield Fork and Gualala River		2				45		
Junction North Fork and Gualala River						95		
Garcia River, near mouth	1				1	38		
Garcia River, 5 miles from mouth						45		
Garcia River, 10 miles from mouth	1					50		
Alder Creek						60		
Navarro River, 4 miles above mouth						9		
Navarro River, near Philo				1		35		
Navarro River, near Boonville	1			1				49
Albion River, near Comptche			4		4	55		
Big River, 7 miles above mouth		16		6		150		
South Fork of Big River							1	7
Noyo River	4					125		
Ten Mile River	9		33		20	100		
Maple Creek							13	
Usal Creek							23	
Mattole River, White Thorn	2							
Mattole River, Petrolia							16	
Bear River, Capetown							3	
Van Duzen Creek							21	
South Fork Eel River, Myers							22	
Elk River					28	83		
Mad River, near mouth							6	2
Redwood Creek, near mouth							37	
Klamath River, near mouth							5	
Smith River, near mouth							7	
Coquille River, near mouth						7	54	15
Deer Creek, Roseburg	3							
North Umpqua, Winchester	1					12		
Takenitch Creek, near mouth	55	8	1	1		15		
Nehalem River, near mouth						3		
McKenzie River, near Eugene	25							
The Lakes, Albany	15							

34. **Hysterocarpus traski** Gibbons.

Not known from the streams north of the Russian River.

Russian and Napa rivers.

35. **Cottus asper** Richardson.

The extent of the prickly investment of the body is subject to considerable variation in this species. This variation often appears between specimens from different streams, but it is also common among individuals from the same stream. Usually the entire body, except the breast, abdomen, and caudal peduncle, is closely covered with rather coarse prickles. Often this armed area is reduced to a spot no larger than the pectoral fin, while occasionally it is much smaller. No entirely smooth examples have been seen. In rare instances a loss of the palatine teeth accompanies a great reduction of the prickly area. Two preopercular spines are always present. A third very small one sometimes appears below them.

The species is commonly found in the lower courses of the streams, often being abundant in brackish or even salt water. It frequents deep, quiet pools, apparently being partial to a muddy bottom.

Specimens were collected in nearly every river basin between the Columbia and Sacramento.

FIN CHARACTERS AND EXTENT OF PRICKLY INVESTMENT OF 139 SPECIMENS OF COTTUS ASPER.

Locality.	Number of specimens with—																Extent of prickly investment of skin.
	8 dorsal spines.	9 dorsal spines.	10 dorsal spines.	18 dorsal rays.	19 dorsal rays.	20 dorsal rays.	21 dorsal rays.	22 dorsal rays.	16 anal rays.	17 anal rays.	18 anal rays.	19 anal rays.	15 pectoral rays.	16 pectoral rays.	17 pectoral rays.	18 pectoral rays.	
Lake Washington, Wash.	2	15	....	....	2	8	7	....	4	12	1	....	....	2	5	....	Entire upper parts except caudal peduncle.
Columbia River, Astoria.	1	5	1	....	1	1	5	....	4	3	....	....	....	5	2	....	Do.
The Lakes, Oregon City.	1	9	....	....	....	....	10	....	....	5	5	....	....	....	....	....	Do.
Nestucca River	....	10	....	....	....	1	5	4	1	6	3	....	1	9	....	....	Entire upper parts except caudal peduncle; area often reduced to size of pectoral fin.
Takenitch River	....	16	....	....	....	8	3	5	3	9	4	....	....	11	5	....	Do.
Coquille River	....	8	....	....	....	3	5	....	....	7	1	....	2	4	2	....	Do.
Flores Creek	....	12	....	....	....	1	6	5	....	6	5	1	....	6	3	3	Area size of pectoral or somewhat larger.
Rogue River, near mouth.	....	8	....	....	....	2	5	1	1	6	1	....	1	5	2	....	Entire upper parts, except caudal peduncle, often reduced to area no larger than pectoral.
Smith River	1	3	....	....	....	1	3	....	2	2	....	....	....	4	....	....	Do.
Mad River	1	5	....	....	....	5	1	....	1	5	....	....	2	4	....	....	Do.
Redwood Creek	1	3	....	....	....	2	2	....	....	4	....	....	2	2	....	....	Area size of pectoral.
Eel River	....	4	....	....	....	....	3	1	....	2	2	....	....	3	1	....	Do.
Garcia River	....	6	....	....	....	4	2	....	4	1	1	....	3	3	....	....	Entire upper parts except caudal peduncle.
Navarro River	2	9	....	....	2	7	2	....	6	5	....	....	2	8	1	....	Do.
Gualala River	1	8	....	....	....	6	3	....	4	5	....	....	2	7	....	....	Do.
Paper Mill Creek, Marine County, Cal.	1	8	1	1	1	8	....	....	9	1	....	....	....	9	1	....	Entire upper parts, except caudal peduncle, often reduced to area half the size of pectoral.

36. Cottus gulosus (Girard).

Cottus gulosus has been confused by recent authors with *Cottus asper* Richardson, the name *gulosus* having been applied to examples of *C. asper* from the Sacramento and neighboring streams which were erroneously supposed to differ from representatives of the same form from the Columbia. *Cottus gulosus* or *Cottopsis gulosus* described by Girard [a] is a species differing from *C. asper*, notably in having a much shorter anal fin. It now appears that the species *C. gulosus* extends northward at least to the Columbia and includes the form known as *Cottus perplexus*, specimens of which do not differ from examples of *C. gulosus* from the Sacramento. In the Klamath basin *C. gulosus* is represented by *Cottus klamathensis*, which seems to be a slightly distinct form, or at least should be so considered until certain characters which now appear to be distinctive are shown to be unreliable. *C. gulosus* is also closely related to *Cottus punctulatus* and *Cottus beldingi*. A careful examination of the relationships of these forms will no doubt be fruitful.

C. gulosus occurs in most of the coastwise streams between the Sacramento and Columbia rivers, with possibly the single exception of the Klamath. It is usually to be found in the upper courses of the rivers, although it is not uncommonly associated with *C. asper* and *C. aleuticus* farther downstream.

In *C. gulosus* the preopercle is always armed with one strong spine which is curved or pointed upward, the size of the spine, its curvature, and the angle of inclination varying somewhat in different individuals. It is often nearly cylindrical in shape, while again it may be rather broad and flat, possibly inclining toward the cylindrical form in southern examples, and being more often flat in the northern ones. There is also present a second comparatively weak spine which varies considerably in size, being sometimes reduced to a mere prominence or in rare instances disappearing entirely. Occasionally a third spine appears below the others. The palatine bones are usually without teeth, although in some cases a small patch of minute teeth may be seen. The presence or absence of teeth

[a] *Cottopsis gulosus* Girard, Proceedings Academy Natural Sciences, Philadelphia, vol. VII, 1854, p. 129.

appears to bear no relation to the armature of the preopercle or to the condition and extent of the prickly investment of the skin. The skin is commonly smooth. A restricted axillary area of fine prickles is often present, being in some examples prolonged posteriorly to the origin of the anal. The lateral line is incomplete, ending at some point below the base of the soft dorsal. Rare exceptions have the lateral line complete or nearly so. The dorsal fins are generally joined by a membrane which extends about halfway up the first articulated ray. The width of the connecting membrane varies greatly and specimens are frequently met with in which it scarcely rises above the base of the first ray. The upper pectoral rays are occasionally branched. The color varies considerably, although some modification of the same general pattern is always preserved. Other slightly variable features, as the shape of body, the length of fins, number of rays, etc., are indicated in the appended tables. The variations here described are not greater than are commonly found among individuals of a widely distributed species, and while extremes of variation in certain characters may be seen among specimens of one locality, they are perhaps more often exhibited by examples from different basins.

Fin Characters of Cottus gulosus.

Locality.	Number of spines in dorsal—				Number of rays in dorsal—					Number of rays in anal—					Number of rays in pectoral—				
	6.	7.	8.	9.	16.	17.	18.	19.	20.	12.	13.	14.	15.	16.	13.	14.	15.	16.	17.
Holmans Creek, Oregon	....	1	5	2	....	....	....	8	....	....	....	3	5	....	....	....	6	2	....
Klaskanine River, Oregon	....	....	13	2	....	4	9	2	....	....	....	2	10	3	....	....	12	3	....
McKenzie River, Oregon	....	1	5	2	....	1	4	3	....	....	....	....	8	....	....	4	4	....	....
Nehalem River, Oregon	....	....	16	....	....	1	8	7	....	....	1	1	14	....	....	3	10	2	1
Tillamook River, Oregon	....	....	19	1	....	1	10	9	....	....	....	3	13	4	....	14	6	....	....
Siletz River, Oregon	....	2	4	....	....	2	1	3	....	....	1	3	2	....	....	4	2	....	....
Deer Creek, Roseburg, Oreg	....	....	5	....	....	....	3	2	....	....	....	....	5	....	....	5	....	....	....
Elk Creek, Drain, Oreg	....	1	9	....	....	2	4	4	....	....	....	4	6	....	....	7	3	....	....
Cow Creek, Oregon	....	....	3	....	....	1	2	....	....	....	....	3	....	....	....	3	....	....	....
Coquille River, Oregon	....	1	9	....	2	6	2	....	....	....	2	7	1	....	....	5	5	....	....
Rogue River, Grants Pass, Oreg	....	2	7	1	....	6	4	....	....	....	....	7	3	....	....	7	3	....	....
Butte Creek, Oregon	....	....	9	1	....	7	3	....	....	....	....	9	1	....	1	8	1	....	....
Bear Creek, Ashland, Oreg	....	1	9	....	....	4	5	1	....	....	....	6	4	....	....	7	3	....	....
Noyo River, California	....	7	24	1	1	13	13	5	....	....	24	7	1	....	7	21	4	....	....
South Fork Big River, California	....	1	3	....	....	3	1	....	....	....	4	....	....	....	3	1	....	....	....
Warm Springs Creek, California	....	....	6	....	....	3	3	....	....	....	5	1	....	....	....	1	4	1	....
Knights Valley Creek, California	....	3	12	....	....	4	11	....	....	1	7	5	2	....	....	5	9	1	....
Napa River, California	....	3	18	1	....	12	10	....	....	....	9	12	1	....	....	4	17	1	....
McCloud River, Baird, Cal	....	....	6	....	....	3	3	....	....	....	4	2	....	....	....	1	5	....	....
Berryessa Creek, California	....	....	3	1	....	2	2	....	....	....	3	1	....	....	2	2	....	....	....
Ætna Springs Creek, California	....	1	5	1	....	1	5	1	....	....	2	5	....	....	3	3	1	....	....

Measurements of Cottus gulosus.

	Columbia River basin.												
	Skookumchuck Creek, Chehalis, Wash.			Holman Creek, Ilwaco, Wash.					Klaskanine River, Olney, Oreg.				
Length of body ...mm.	60	50	57	69	74	71	69	66	71	74	72	60	51
Length head	.335	.34	.33	.33	.34	.34	.32	.33	.33	.32	.32	.34	.33
Depth body	.245	.26	.25	.235	.23	.24	.23	.23	.26	.22	.22	.30	.26
Depth caudal peduncle	.10	.10	.09	.095	.09	.09	.09	.085	.105	.09	.085	.10	.10
Length caudal peduncle	.135	.14	.13	.13	.12	.13	.13	.13	.13	.12	.125	.12	.13
Length snout	.095	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	105	.10
Length maxillary	.13	.13	.13	.14	.15	.14	.135	.13	.15	.15	.14	.14	.145
Diameter eye	.08	.085	.08	.08	.08	.08	.075	.08	.075	.085	.075	.085	.09
Interorbital width	.05	.055	.055	.05	.06	.05	.05	.045	.055	.05	.055	.06	.05
Depth head	.21	.20	.205	.21	.22	.20	.22	.21	.22	.195	.19	.22	.21
Snout to dorsal	.38	.41	.37	.39	.38	.40	.37	.37	.38	.38	.38	.41	.38
Snout to anal	.56	.56	.54	.55	.56	.58	.60	.56	.56	.58	.59	.58	.59
Length base of spinous dorsal	.18	.165	.16	.20	.18	.17	.18	.18	.20	.18	.185	.18	.205
Length base of soft dorsal	.43	.46	.43	.43	.41	.39	.43	.40	.41	.42	.44	.40	.39
Length base of anal	.34	.35	.33	.34	.34	.32	.31	.33	.34	.33	.34	.335	.33
Height spinous dorsal	......	.115	.12	.11	.10	.10	.09	.11	.09	.10	.095	.09	.11
Height soft dorsal	.16	.17	.16	.16	.16	.14	.16	.15	.16	.15	.14	.155	.16
Height anal	.14	.14	.14	.14	.15	.14	.14	.14	.14	.14	.125	.14	.13
Length pectoral	.27	.26	.26	.28	.28	.30	.29	.27	.28	.27	.28	.27	.28
Length ventral	.21	.21	.20	.20	.21	.20	.19	.19	.19	.19	.20	.21	.21
Length caudal	.26	.27	.24	.23	.24	.235	.24	.24	.25	.25	.23	.26	.26

MEASUREMENTS OF COTTUS GULOSUS—Continued.

	Nehalem River basin.					Rogue River basin.				
	Nehalem River.					Bear Creek, Ashland, Oreg.				
Length of body.....mm..	67	65	67	58	60	57	60	63	63	56
Length head	.31	.32	.32	.33	.34	.315	.325	.31	.31	.31
Depth body	.22	.24	.22	.22	.21	.22	.23	.23	.23	.23
Depth caudal peduncle	.09	.10	.09	.10	.09	.085	.085	.09	.09	.09
Length caudal peduncle	.135	.135	.13	.13	.12	.125	.13	.14	.14	.14
Length snout	.105	.10	.10	.105	.10	.10	.11	.10	.10	.10
Length maxillary	13	.13	.13	.13	.13	.14	.15	.125	.14	.12
Diameter eye	.075	.07	.08	.08	.08	.08	.075	.07	.08	.08
Interorbital width	.04	.045	.04	.045	.04	.04	.04	.04	.045	.04
Depth head	.20	.20	.20	.20	.19	.18	.20	.20	.20	.19
Snout to dorsal	.37	.37	.37	.38	.36	.36	.375	.36	.37	.36
Snout to anal	.56	.55	.56	.56	.56	.57	.56	.53	.56	.55
Length base of spinous dorsal	.17	.17	.17	.16	.17	.18	.20	.18	.17	.18
Length base of soft dorsal	.40	.43	.42	.435	.42	.43	.41	.39	.40	.41
Length base of anal	.35	.34	.35	.33	.36	.32	.33	.33	.32	.35
Height spinous dorsal	.10	.10	.10	.11	.10	.105	.11	.09	.10	.10
Height soft dorsal	.14	.17	.15	.135	.15	.135	.14	.13	.15	.15
Height anal	.15	.135	.15	.13	.12	.135	.13	.12	.14	.13
Length pectoral	.28	.27	.29	.28	.26	.29	.31	.29	.28	.30
Length ventral	.20	.21	.20	.19	.20	.20	.21	.19	.19	.20
Length caudal	.24	.23	.23	.24	.24	.235	.22	.21	.22	.24

	Noyo River basin.									
	Noyo River, Cal.									
Length of body.....mm..	46	48	49	50	50	51	53	54	55	62
Length head	.33	.34	.35	.34	.34	.35	.36	.36	.35	.36
Depth body	.22	.23	.24	.25	.24	.22	.25	.23	.24	.25
Depth caudal peduncle	.08	.08	.085	.09	.09	.09	.09	.09	.08	.08
Length caudal peduncle	.14	.13	.14	.12	.13	.13	.13	.13	.12	.12
Length snout	.10	.095	.11	.11	.10	.11	.11	.11	.10	.10
Length maxillary	.13	.13	.12	.13	.14	.13	.15	.15	.145	.145
Diameter eye	.08	.09	.09	.08	.085	.09	.09	.09	.095	.09
Interorbital width	.035	.04	.04	.04	.04	.035	.04	.045	.04	.04
Depth head	.20	.20	.21	.20	.20	.20	.20	.21	.20	.20
Snout to dorsal	.37	.39	.41	.38	.38	.38	.41	.40	.40	.40
Snout to anal	.56	.56	.56	.56	.55	.57	.60	.60	.58	.60
Length base of spinous dorsal	.17	.18	.17	.19	.20	.18	.17	.21	.19	.19
Length base of soft dorsal	.44	.43	.41	.41	.40	.44	.44	.42	.44	.45
Length base of anal	.32	.29	.28	.31	.31	.32	.31	.29	.28	.32
Height spinous dorsal	.10	.10	.09	.10	.10	.09	.10	.10	.10	.10
Height soft dorsal	.15	.15	.15	.15	.15	.14	.18	.15	.15	.15
Height anal	.125	.15	.14	.16	.14	.14	.16	.15	.14	.15
Length pectoral	.29	.31	.33	.29	.30	.29	.29	.30	.29	.32
Length ventral	.22	.23	.21	.21	.21	.21	.21	.23	.23	.22
Length caudal	.26	.26	.25	.23	.24	.24	.24	.25	.25	.24

	Sacramento River basin.									
	Napa River, Calistoga, Cal.									
Length of body.....mm..	59	61	61	61	64	67	67	68	74	75
Length head	.35	.35	.35	.36	.35	.35	.35	.335	.36	.35
Depth body	.27	.29	.28	.28	.27	.28	.27	.27	.30	.27
Depth caudal peduncle	.09	.10	.085	.09	.10	.09	.09	.09	.10	.10
Length caudal peduncle	.12	.12	.12	.13	.14	.13	.11	.12	.105	.115
Length snout	.10	.11	.10	.10	.09	.09	.10	.10	.10	.10
Length maxillary	.13	.14	.13	.135	.145	.135	.135	.13	.15	.15
Diameter eye	.07	.07	.065	.07	.07	.065	.07	.07	.07	.065
Interorbital width	.05	.04	.045	.05	.05	.055	.05	.05	.055	.06
Depth head	.215	.22	.21	.215	.21	.21	.21	.21	.225	.22
Snout to dorsal	.385	.38	.38	.38	.37	.37	.37	.37	.39	.38
Snout to anal	.56	.57	.57	.57	.55	.56	.58	.55	.56	.57
Length base of spinous dorsal	.22	.21	.20	.215	.215	.22	.20	.21	.21	.19
Length base of soft dorsal	.43	.47	.44	.42	.42	.42	.45	.44	.43	.42
Length base of anal	.35	.32	.31	.32	.30	.31	.29	.32	.33	.31
Height spinous dorsal	.11	.09	.12	.115	.10	.10	.07	.10	.105	.10
Height soft dorsal	.16	.15	.15	.16	.16	.16	.16	.15	.15	.16
Height anal	.14	.14	.15	.15	.15	.14	.15	.14	.135	.14
Length pectoral	.28	.26	.30	.26	.30	.30	.30	.29	.27	.27
Length ventral	.19	.20	.20	.20	.19	.19	.20	.19	.19	.19
Length caudal	.24	.25	.24	.25	.25	.23	.25	.225	.24	.24

37. Cottus klamathensis Gilbert.

Specimens of this species from many widely separated localities in the Klamath system have been examined, and with scarcely an exception they have but one preopercular spine, below which the edge of the preopercle is entirely smooth. In rare instances there appears below the preopercular spine a small elevation not unlike that found in the uncommon, single-spined individuals of *C. gulosus*. A comparison also of the dorsal fins of this species with those of *C. gulosus* shows that in *C. klamathensis* the dorsal more often has 7 spines and 19 rays, while in *C. gulosus* there are most frequently 8 spines and 17 or 18 rays.

Fin Characters of 46 Specimens of Cottus klamathensis.

Locality.	6 dorsal spines.	7 dorsal spines.	8 dorsal spines.	17 dorsal rays.	18 dorsal rays.	19 dorsal rays.	20 dorsal rays.	13 anal rays.	14 anal rays.	15 anal rays.	14 pectoral rays.	15 pectoral rays.	16 pectoral rays.
Shasta River, near Montague.	1	23	2	1	7	16	2	5	19	2	3	23	......
Shasta River, near Yreka....	......	16	4	......	6	14	......	5	14	1	4	15	1

Measurements of Cottus klamathensis.

	Shasta River near Yreka, Cal.					Shasta River near Montague, Cal.					
Length of body......mm..	75	68	57	61	57	73	65	55	65	71	50
Length head	.325	.32	.34	.335	.32	.31	.31	.32	.32	.32	.31
Depth body	.21	.24	.25	.26	.21	.24	.24	.26	.25	.30	.25
Depth caudal peduncle	.10	.10	.105	.10	.10	.09	.10	.10	.10	.11	.10
Length caudal peduncle	.15	.14	.13	.145	.14	.14	.13	.12	.14	.13	.15
Length snout	.11	.10	.12	.11	.10	.095	.11	.11	.10	.105	.10
Length maxillary	.145	.14	.15	.14	.13	.14	.145	.14	.13	.14	.13
Diameter eye	.08	.07	.08	.085	.085	.085	.08	.085	.08	.08	.085
Interorbital width	.04	.04	.045	.04	.05	.045	.05	.04	.04	.05	.05
Depth head	.21	.22	.24	.215	.20	.20	.21	.21	.20	.21	.20
Snout to dorsal	.37	.38	.39	.39	.36	.36	.36	.37	.36	.38	.37
Snout to anal	.54	.60	.60	.57	.57	.54	.58	.56	.57	.56	.59
Length base of spinous dorsal	.16	.16	.17	.16	.16	.17	.15	.17	.17	.18	.16
Length base of soft dorsal	.39	.43	.43	.41	.43	.46	.41	.45	.425	.43	.41
Length base of anal	.33	.325	.33	.335	.33	.31	.33	.35	.33	.31	.32
Height spinous dorsal	.08	.085	.11	.08	.09	.11	.09	.10	.10	.11	.11
Height soft dorsal	.135	.14	.13	.14	.15	.15	.14	.16	.14	.14	.15
Height anal	.125	.12	.13	.13	.14	.12	.13	.13	.13	.13	.12
Length pectoral	.27	.28	.28	.28	.27	.28	.28	.32	.28	.27	.27
Length ventral	.18	.18	.20	.19	.19	.18	.19	.20	.185	.19	.18
Length caudal	.21	.22	.22	.23	.22	.23	.22	.25	.23	.22	.22

38. Cottus aleuticus Gilbert.

This species has been hitherto recorded from the Aleutian Islands and Vancouver. Specimens were recently taken by Mr. A. W. Greeley in the Carmel River just south of Monterey Bay, the range of the species being thus materially extended. These and other examples secured at various points along the Oregon and California coast have been compared with the types of *C. aleuticus* and appear not to differ in any respect.

Usually the body is perfectly smooth, the palatines without teeth, and the preopercle with but 1 spine. Spec mens from Maple Creek, California, were found to have a small axillary patch of very fine prickles and a second, minute, blunt spine on the preopercle.

The species is not commonly found. It appears to be confined to the lower courses of the rivers near the sea, where it is often associated with *C. asper*. From *C. asper* and from *C. gulosus* it may be easily distinguished by its tubular nostrils.

Specimens were collected in the following rivers: Tillamook, Trask, Nestucca, Yaquina, Coquille, Elk, Sixes, Pistol, Smith, Redwood, Mattole, Navarro, Alder, Garcia, and Gualala.

FIN CHARACTERS OF COTTUS ALEUTICUS.

Locality.	Specimens having—											
	8 dorsal spines.	9 dorsa spines.	10 dorsal spines.	18 dorsal rays.	19 dorsal rays.	20 dorsal rays.	12 anal rays.	13 anal rays.	14 anal rays.	13 pectoral rays.	14 pectoral rays.	15 pectoral rays.
Tillamook River	3	4	....	1	5	1	....	5	2	2	5	....
Trask River		4		1	3			3	1		4	
Nestucca River	1	4	....	3	1	1	1	4	....	....	4	1
Elk River, Curry County, Oreg	1	1	....	1	1	....	....	1	1	....	2	....
Pistol River			1	1				1			1	
Rogue River	....	2	....	1	....	1	....	1	1	....	2	....
Alder Creek	2			4	1		1	4			5	
Maple Creek	4	6	....	2	7	1	....	10	....	....	5	5
Albion River	....	1	....	....	1	....	....	1	....	....	1	....
Smith River	2	1	....	2	....	1	1	2	....	2	1	....
Garcia River	....	12	....	4	7	1	2	8	2	1	10	1
Gualala River	3	2	1	2	4	....	2	3	1	1	5	.....

39. Cottus rhotheus Rosa Smith.

Specimens of this species were collected in the Willamette basin.

Abert L
Chewaucan R.
Summer L
Silver L
Sprague R
Crater L
Klamath L
Mc Kenzie R.
Middle Fork
Callapoola Cr.
North Fork
South Fork
Cow Cr.
Siuslaw R.
Tsiltcoos R.
Tahkenitch R.
Umpqua R.
Coos R.
Coquille R.
Flores Cr.
Sixes R.
Elk Cr.
Rogue R.
Illinois R.
Pistol R.
Yaquina R.
Alsea R.
Callapooya R.

MAP SHOWING DISTRIBUTION OF FLUVIAL FISHES IN THE COASTAL STREAMS OF OREGON AND NORTHERN CALIFORNIA.

NATURAL HISTORY, ORGANIZATION, AND LATE DEVELOPMENT OF THE TEREDINDÆI, OR SHIP-WORMS

By CHARLES P. SIGERFOOS
Professor of Zoology, University of Minnesota

BUREAU OF FISHERIES DOCUMENT NO. 639

NATURAL HISTORY, ORGANIZATION, AND LATE DEVELOPMENT OF THE TEREDINIDÆ, OR SHIP-WORMS.

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INTRODUCTION.

The ship-worms were favorite objects for study during the eighteenth century on account of the great damage they worked to the dikes of Holland in 1733 and in subsequent years. The first modern observations were those of Valisnieri (1715) and Deslandes (1720). After 1733 came Mossuet, J. Rousset, and especially Godfrey Sellius. These observers seem to have been unaware of the ancient observations mentioned by Theophrastus, Pliny, and Ovid, and it was supposed that the ship-worms were natives of India, whence they had been brought by shipping in modern times. It was Godfrey Sellius who first recognized their molluscan characters, but these were not recognized by Linnæus, who grouped the ship-worms, and *Dentalium*, along with *Serpula*. Cuvier and Lamarck adopted the view of Sellius, and since their time these animals have been put in their proper place.

The first reliable observations on the anatomy of the ship-worms were made by Deshayes, who gave a number of beautifully executed plates to *Teredo* in his "Mollusques d'Algerie", 1848. Like most of the plates of this great work, however, these are difficult to study and interpret. Supplementing the work of Deshayes is that of Quatrefages (1849), who began and completed his observations before he had access to the published results of Deshayes. This "Memoire sur le Genre Taret (*Teredo* Linn.)" is the one usually cited at the present time, although the paragraph with which Quatrefages prefaces his paper is almost as applicable now (with slight changes in the wording) as when it was written. "Naturalists up to the present time," he says, "have strangely neglected Teredo. This is not the place to review the anatomical researches of the last century, which are filled with errors excusable by the state of science of that period. But it is surprising that a mollusk with such remarkable external characters has not been the object of any special research from the foundation of comparative anatomy up to

[a] My work on the ship-worms was first suggested by Prof. W. K. Brooks. His constant interest throughout my stay at Johns Hopkins University was of great help to me and it gives me great pleasure to acknowledge my indebtedness to him. My material was collected at Beaufort, N. C., during the summers of 1895 and 1896, and my study was continued in the laboratory in Baltimore. To the authorities of Johns Hopkins University I am under deep obligations, both for the privileges of the marine laboratories at the seaside and for the facilities for work in the laboratory in Baltimore.

the present time. It is necessary to come to the year 1846 to find a naturalist who has taken for the subject of his observations this mollusk so unfortunately celebrated."

Since the appearance of this memoir of Quatrefages no detailed account of the whole organization of *Teredo* has appeared. Only in comparative treatises has it been taken up. The principal of these are the papers by Grobben (1888), on the pericardial glands in lamellibranchs; by Menegaux (1889), on the circulatory system in lamellibranchs, and by Pelseneer (1891), in his extensive comparative studies in the group. Grobben first observed the anterior adductor muscle in *Teredo* and proved the Teredinidæ to be dimyarians. Aside from this point, the figure of *Teredo* that he gives is wholly unreliable. Menegaux attempted to establish the homologies of the aortæ, and Pelseneer described the visceral ganglion and related structures. I shall have occasion to refer to these papers in special parts later, and it will be seen that the comparative method of study is not always satisfactory if the examination of the different forms be not made with sufficient thoroughness. My results differ from all of these. Unfortunately, the first two authors do not state the species on which their observations were made, and so I can not state that where my observations differ from theirs they were in error. There is, however, such great uniformity of organization in the various species that we may expect only differences in detail.

My observations have been based chiefly on *Xylotrya gouldi* Bartsch, and in the present paper except where otherwise stated this is the form described and figured. I have had specimens in all stages of development from the newly attached larva to the adult. I have also studied *Teredo dilatata* Stimpson and *T. navalis* Linnæus, and these have been used where they are essentially different or more favorable for description.

The object of my study of the ship-worms has been twofold. In the first place, I have endeavored, by the use of modern methods, to make a detailed study of the organization of this highly specialized lamellibranch and to correct some errors that have heretofore existed in the descriptions of it. In the second place, by the study of young stages, I have been able to trace the transformation of the typical lamellibranch larva into the very highly specialized ship-worm.

I have also traced the early embryology with the artificially fertilized eggs of *X. gouldi* and *T. dilatata*, in both of which the eggs are laid free into the water. Stages later than the typical early lamellibranch veliger, raised in aquaria, I have not been able to observe. The intermediate stages, between these and the newly attached larva, I hope to observe on the larvæ of some viviparous species at a future time, so as to complete my study of the development from the egg to the adult.

Methods of preserving material.—My preserved material was collected and prepared for study as follows: By hanging boxes and other structures of wood in the water at Beaufort, I was able to obtain all stages, from the newly attached larvæ to ship-worms 4 inches long, with adult organization. The youngest stages were collected from the surface of the wood. Later stages were dissected out of the wood into which they had bored. Early stages were narcotized with cocaine and afterwards fixed with mercuric chloride. Specimens 1 cm. or more in length were treated as follows: They were exposed quickly in their burrows and

immediately a quantity of Hermann's solution was dashed upon them. This reagent kills them instantly, before they have had time to contract appreciably. They were then immediately immersed in mercuric chloride or Perenyi's solution for fixation. After washing in weaker alcohols, specimens were preserved in 90 per cent alcohol. The early stages were stained in Kleinenberg's hematoxylin. For later stages, the best results were obtained by staining in bulk with borax-carmine, followed by staining sections with Lyons blue. For the examination of the younger stages as whole objects, the best results were obtained by staining in a weak solution of borax-carmine in acid ($\frac{1}{2}$ per cent HCl) 70 per cent alcohol, which decalcifies as well as stains.

With the exception of a few diagrams, which are indicated as such, the figures of sections have been drawn with the aid of a Zeiss camera lucida. In some cases, as in the series of transverse sections of the adult (fig. 28–35), they have been "touched up" afterwards. In no case, however, have they been essentially modified, and they are in no wise diagrams. The figures to illustrate the adult structure have been made from specimens about 10 cm. long, which I had raised, and which were killed almost perfectly extended. The siphons, however, have been filled in from life and from preserved specimens that had been narcotized before killing. In large specimens the body as a whole and the various organs are somewhat more elongated comparatively, but the relations remain the same as in younger specimens.

NATURAL HISTORY.

Any wooden structures that one may examine at Beaufort which have been in the water for some time and unprotected are found infested with ship-worms. These are of three species, which Dr. Paul Bartsch has kindly identified for me as *Xylotrya gouldi* Jeffreys, *Teredo navalis* Linnæus, and *T. dilatata* Spengler. *X. gouldi* and *T. dilatata* are very abundant, while *T. navalis* was found but rarely. *X. gouldi* is the most abundant of all, and is found everywhere. It may attain a length of 2 feet or more, though where it grows in large numbers it is so crowded that old specimens are often less than a foot in length. *T. dilatata* I have found mostly in the heavier piles of wharves, where specimens may attain the great size of 4 feet in length and an inch in diameter at the anterior end. *T. navalis* I have found very sparingly, not over a dozen specimens among the thousands of individuals I have examined. These in all cases were small specimens, from which it seems that the habitat at Beaufort is not favorable for them and is more favorable for the other two species, which fully occupy all of the available places for ship-worm life. The water contains a high percentage of salt, and the warm season is long. These factors may account wholly or in part for the comparative absence of *T. navalis*.

Of the thousands of young ship-worms (under 4 inches in length) I have taken from boxes, all except four specimens of *T. navalis* were *X. gouldi*. These were observed in June, July, and the first half of August. Whether the absence of younger specimens of *T. dilatata* during these three months was due to unfavorable locations, or the season for attachment is different from that of the other two species, I was not able to determine. I am inclined to think that the spawning season of *T. dilatata* is different from that of *Xylotrya*.

BREEDING HABITS.

As is well known, some species of ship-worms retain their eggs in the gills during their embryonic development. This is true of *T. navalis*, and even the small (an inch or two in length) specimens of this species I have taken have usually carried embryos in various stages of development. On the other hand, I have found that the eggs of the other two species are laid free into and fertilized in the water. If species of *T. dilatata* be taken from their tubes, they soon begin to extrude their sexual products, if these be mature. The eggs and spermatozoa are extruded from the anal or exhalent siphon in a slow, steady stream, which continues as long as the reproductive organs contain ripe sexual products. *Xylotrya gouldi* I have observed but rarely extruding its sexual products in this manner, but why there is a difference in this habit I have not determined.

In association with their character of free development in the water, the eggs of the ship-worm are very small and very numerous. While they vary somewhat in size, they have an average diameter of somewhat less than $\frac{1}{20}$ mm. ($\frac{1}{500}$ inch). Very large ship-worms may lay great numbers of eggs at one time. In one case I estimated the number laid by a large female of *T. dilatata* to be one hundred millions. The spermatozoa are very minute, and much more numerous than the eggs. The eggs of both species that lay their eggs into the water may be fertilized artificially, and develop with great uniformity and rapidity in aquaria. The eggs when first laid are of irregular shapes, but they soon become spherical and, if fertilized, the polar bodies are soon extruded and segmentation begins. Development is very rapid and on warm days the embryos become free-swimming within three hours after the eggs are laid. Within a day the shell has been formed and the typical lamellibranch veliger stage is reached. Beyond this stage I could not rear them in aquaria, though they may live for days afterwards. Hatschek has observed (1880) that the viviparous larvæ of a species studied by him (? *T. navalis*) are almost always present in only a few stages, and that transitional stages are but seldom found. It seems probable that the free-living larvæ of *Xylotrya* and *T. dilatata* attain one of these stages within a short time, and that the unusual conditions in aquaria prevent their advance beyond it.

The mode of life of the larvæ and the rate of development beyond the early stage attained so rapidly in aquaria have not been determined. What becomes of the larvæ after hatching from the eggs, how and where they live, it is difficult to surmise. Though the developed larvæ are settling on wooden structures constantly, I have not taken them and the intermediate stages in the tow-net, and where they develop I do not know. The rate of growth of larvæ of the marine lamellibranchs, however, is slow, and I think the larvæ of ship-worms when they attach themselves must be at least a month old. They may be more, for at this time their development is quite advanced and their organization complex. (See the description of the organization of the larva, p. 201.)

The breeding period of *X. gouldi* and *T. dilatata* seems to extend throughout the warm season. I have found ripe sexual products of both species from early in May till the middle of August. At the latter time there seemed no abatement in

their development. As will be described later, individuals become sexually mature in a month after they have attached, and those which attach in August must bear ripe sexual products later in the season, so that the breeding period would seem to extend throughout the warmer months.

ATTACHMENT OF THE LARVA.

During its free mode of life, the ship-worm larva has gradually developed into the larva typical of marine lamellibranchs. There is a bivalve shell into which the whole creature can be withdrawn for protection; a large swimming organ, the velum, by means of which the larva swims freely in the water; a long, powerful foot, by means of which it crawls actively over surfaces; and the internal organization peculiar to advanced lamellibranch larvæ. At the end of this larval development, in fact, the ship-worm larva is a typical small bivalve, except that it possesses the swimming organ.

Throughout the summer (or at least from May till the middle of August) at Beaufort, if one examines fairly clean, unprotected wooden structures submerged in the water, very small bivalves will be found crawling actively over the surfaces. These are very minute and are easily recognized as ship-worm larvæ that have just settled upon the wood. The larva moves rapidly in search of a favorable place for attachment, and this is usually in some minute depression or crevice in the wood, though it may become attached to perfectly smooth surfaces. It seems to possess no organ of special sense for the purpose, and yet it is able to determine what places are favorable for its future life and to avoid those which are not. Once it has chosen a point for attachment it throws out a single long byssus thread, thus securing itself to the surface of the wood, and very soon loses its velum, so that it can no longer lead a free-swimming life. Once attached, the larva begins to clear away a place for its burrow by scraping away the surface of the wood with the ventral edges of its shell valves. Such small particles of wood and other substances as are thus collected are cemented together over the larva so as to form a sort of conical covering for protection. This formed, the further transformation of the larva into the small ship-worm begins and progresses rapidly. The foot becomes a pestle-shaped organ which assists the shell in burrowing. The shell valves lose their power of opening at the ventral side and, by the development of knobs on the ventral and dorsal portions of both valves, are able to swing upon each other at right angles to the former direction. Meanwhile, because of the rapid growth of the valves on their ventral edges, the shell gapes at both anterior and posterior ends, for the protrusion of the foot in front and the siphons (and later the body) behind; and on the external surface of the valves at the anterior edges has been formed the first row of the small teeth which at this and later stages are the mechanical agents by which the animal bores into the wood. This transformation has taken place within two days from the time the larva has settled, and afterwards the animal rapidly becomes an elongate ship-worm, enlarging its burrow in the wood as it increases in size.

RATE OF GROWTH WITHIN THE WOOD.

The ship-worm in its larval stages develops slowly, but once in the wood it grows with remarkable rapidity. During its free life most of its energies are devoted to active locomotion and development; after attachment it leads a protected sedentary life and its growth is correspondingly rapid. The newly attached larva is somewhat less than 0.25 mm. long. In 12 days it has attained a length of about 3 mm.; 16 days, 6 mm.; 20 days, 11 mm.; 30 days, 63 mm., and 36 days, 100 mm. It is thus seen that within two weeks from the time it has settled, the ship-worm has increased hundreds of times in volume, and in five weeks thousands of times. Within two weeks it has developed its characteristic form. Even in a month specimens may contain ripe sexual elements, though normally these seem to be retained till larger quantities of spermatozoa and eggs are stored for extrusion at one time. I shall describe later what appears to be a change of sex from males to females, the male sex being developed in young specimens. I have found males four weeks old gorged with ripe spermatozoa, and in every way sexually mature.

The ages of larger specimens I have been able only to estimate from the time the piles and other wooden structures from which they were taken had been in the water. In one case I took specimens of *Teredo dilatata*, 4 feet long and an inch in diameter at the anterior end, from piles that had been in the water less than two years. This was in July, and in this case it seems the worms had entered the wood not earlier than the spring of the preceding year, and hence were little, if any, over a year old.

The rate of growth seems to depend but little, if at all, on the hardness or kind of wood. As is well known, ship-worms penetrate all kinds, whether it be soft white pine or hard oak. In India there are types that bore into stiff clay. None of our species adopt such a habitat, so far as I know, but I have found small, abnormal specimens of *Xylotrya* in very rotten wood, and I take it that their abnormal character was due to the unusual conditions. In this case they were associated with *Xylophaga dorsalis* and *Pholas dactylus*. I have observed, however, that in well-preserved wood they grow quite as rapidly if it is hard yellow pine as if it is soft white pine; so that the rate of growth seems conditioned by food supply and not by the ability of the animal, as regards the hardness of the wood, to form its burrow.

PROTECTIVE ADAPTATIONS.

The life of the ship-worm in the wood has led to profound changes in the character of its external parts and its means of protection. As it enters, the posterior part of the body projects more and more beyond the shell, which loses its protective character in large measure to take upon itself the purpose of burrowing. In specimens 2 mm. long the shell is still a quarter of the total length; in specimens 4 feet long, the shell is an inch or less in length. With the loss of protection of the soft body by the shell other means are acquired. In a general way the wooden wall of the burrow offers the protection afforded by the shell in other mollusks. But the very delicate tissues of the mantle would be injured by the slightest roughness in the surface of the wood. So, as the body elongates, the mantle secretes around

itself a constantly thickening calcareous tube which lines the whole burrow except the extreme anterior end, where the mantle is somewhat less delicate and where the tube fades out and the burrow is being constantly enlarged.

When the young "worm" enters the wood, it penetrates vertically to the surface, cutting across the grain. It soon bends its course, however, so that within 2 inches, usually, it takes a straight course in the direction of the grain. Individuals that enter the wood on end cut with the grain across the fibers from the start, so that their burrows are straight, unless they are turned from their course by obstructions of some sort. In such a case the course is changed so that the burrows may become exceedingly tortuous. When the ship-worm is in danger of burrowing into the tubes of its fellows or into other spaces, if its course can be no longer changed, it contracts the anterior part of the body slightly, secretes a closed calcareous lining in front of it, and ceases to burrow further or to grow. Otherwise, apparently, it may grow indefinitely, and it is difficult to say how large specimens might become were there not adverse conditions to stop their growth.

I believe that the calcareous lining of the burrow has been acquired primarily for the protection of the very delicate body from the rough surfaces of the wood, but it serves other purposes also. It prevents the diffusion of injurious substances into the burrow, and also prevents the intrusion of other creatures that live in the wood. Then, too, when the surrounding wood decays, or is eaten away by other animals inhabiting the wood, so as to endanger the life of the ship-worm, the tube may be so strengthened as to serve as the sole means of external protection. In this way the walls of the calcareous tubes, which, protected, are usually not over a quarter to a half millimeter thick, may become 2 mm. or more thick. This response to changed conditions on the outside is a very mysterious one and it is difficult to see by what means the animal recognizes its dangers.

The peculiar mode of life of ship-worms has led to the development of the pair of pallets (fig. 20). These are protective structures peculiar to the ship-worms. They differ somewhat in the various species, but are essentially calcareous paddle-shaped structures, attached one on either side of the posterior end of the body at the point of origin of the siphons. In *Xylotrya* the expanded part of the paddle consists of a series of funnel-shaped calcareous structures set one within the other upon a cylindrical handle, while in *Teredo* it is composed of a single piece. The handle of the paddle is embedded in a forward evagination of the mantle and the expanded part projects freely behind, where, by means of a set of muscles, they may be protracted forcibly so as completely to close the outer end of the burrow against the intrusion of any enemy from the outside. Also, when the burrow extends upward and its opening is more or less exposed at low tide, as sometimes happens, the pallets may so hermetically close the external opening as to retain the water in the burrow and to prevent the collapse of the body of the ship-worm. The action of the pallets is illustrated in figures 35 and 36. When the animal is undisturbed and feeding, the pallets are drawn forward and the siphons are extended freely into the water, as shown in figure 35. When it is disturbed in any way the siphons are contracted very quickly and the pallets forced into the end of the tube, as shown in figure 36.

MODE OF BURROWING.

The manner of mechanical formation of the burrow has been one of the most debated questions in the natural history of the ship-worms and their allies. In the former this work has been assigned by various observers to various structures. In some cases it was thought some chemical solvent assisted the mechanical action by softening the wood. Hancock thought there were siliceous particles in the mantle to do the work. Quatrefages thought it to be the "cephalic hood" (a thickened modification of the mantle at the anterior end on the dorsal side), aided by some chemical solvent. This structure he described as muscular, though it is but little muscular and could do no such important work as he assigned to it. Jeffreys ascribes this function to the foot, which by other observers was described as wholly absent. Osler, in 1826, had suspected the real mode of formation, though he did not actually observe it.

The shell is the agent, assisted by the foot, as I have actually observed in young specimens under the microscope; and the whole structure of the shell and the arrangement of its adductor muscles confirm this observation. The teeth on the anterior edges of the valves point outward and backward. On both dorsal and ventral portions of each shell valve (fig. 18 and 19) there are stout calcareous knobs which form a double pivot by which the valves are swung upon each other by the contraction of the adductor muscles. The mode of burrowing is as follows: While the foot performs a cupping action, thus drawing the shell close against the surface of the wood, the powerful posterior adductor muscle contracts, so that the teeth on the shell rasp away the wood. The valves are brought to the original position by the small anterior adductor. The comparatively very large posterior adductor is therefore the active agent that does the work, aided by the foot; the shell with its teeth is the tool with which the work is done.

INGESTION OF WOOD AND FOOD.

As in other lamellibranchs, a constant stream of water is passing through the siphons when they are extended from the outer end of the burrow into the water, and this serves for respiration and also contains the small organisms which serve for food. These consist mainly of diatoms and simple floating algæ, with other minute organisms. Small crustacea and other animal forms seem to be almost never eaten.

The particles of wood that are rasped away in forming the burrow are ingested, as the only means of getting rid of them. It has often been debated whether they undergo any digestion in the alimentary canal, and I am inclined to think that they contribute something to the nutrition of shipworms. Boring I believe to be a periodical function, perhaps alternating with more active ingestion of food. This is indicated by two facts. In the first place, it seems that while the new-formed teeth are being cemented to the anterior edges of the valves the shell could not be used. Also, the cæcum of the stomach contains almost wholly particles of wood, which indicates that while the animal is burrowing, the orifice into the cæcum is open. The very large fold of the internal mucous membrane of the cæcum (fig. 29–31) seems so eminently constructed for absorption that I think there must be some digestive action on the particles of wood within it.

ORGANIZATION AND LATE DEVELOPMENT.

In their form and general organization the adult ship-worms are the most peculiar and striking of all the lamellibranchs. Their newly attached larva has the form and essentially the organization of the larva typical of most of the marine lamellibranchs which are free-swimming during their larval development. The transformation of the typical larva into the highly specialized ship-worm is so striking and takes place with such great rapidity as properly to be called a metamorphosis.

THE LARVA.

ORGANIZATION.

The general shape of the newly attached larva (fig. 1) is that of a small clam, with equal shell valves. These latter are broader dorso-ventrally than long, so that this lamellibranch, which is more elongated as an adult, as a larva is more foreshortened, perhaps, than any other form. The youngest specimens I found were creeping over the surface of the wood by means of the very active tongue-shaped foot. The velum was in all cases retracted into the large velar cavity (*vc*), a large space in the anterior dorsal part of the shell cavity. This is best shown in figure 24, which represents a sagittal section of a newly attached larva. The foot (fig. 1, 7, 22) at this stage is very long, ciliated over most of its extent, and angular at its posterior end. This angular portion is occupied by a well-developed though simple byssus apparatus which throws out a single simple byssus thread several times as long as the diameter of the larva. This serves to anchor the larva in the early stages of attachment, so that after the velum has been lost it may still return to its mooring if from any cause it lose its footing.

The siphons are already well developed in the larva, the ventral inhalent or respiratory (*is* fig. 1, 7, 22) with ciliated sensory papillæ; the dorsal exhalent (*es*), a simple nonciliated tube. The gills have advanced but little beyond the stage figured by Hatschek (1880) for the viviparous larva studied by him. On each side of the body there are two large gill-slits, and in the gill membrane the rudiment of a third. The shipworm larva is a typical dimyarian. Both adductor muscles are present in their usual positions, the posterior (fig. 22, *ap*) already considerably larger than the anterior (*aa*). The posterior retractor muscles of the foot at this stage are attached in the umbonal region of the shell, just in front of the posterior adductor muscle.

The alimentary canal is already highly specialized (fig. 7, 22, 23, 24). A comparatively long œsophagus (*oe*) leads into the stomach, from which a single comparatively large liver vesicle projects as a diverticulum on each side. The sheath of the crystalline style (*ss*) projects from the posterior ventral portion of the stomach on the midline. The intestine leaves the stomach from the right side, anteriorly. The cæcum of the stomach, peculiar to the Pholadacea, is present as a small hemispherical rudiment on the right side, just posterior to the opening of the intestine.

The nervous system of the larva (fig. 7 and 59) is already highly specialized. At the sides of the œsophagus are the two cerebral ganglia, separated from each other

by only a snort connective. The pleural ganglia (*pl*) are still separate from the cerebral (*c*) and lie lateral to them. The pedal ganglia (*p*) are high up in the foot and are closely fused together, as in the adult. The two visceral ganglia (*v*) are still wide apart and lie against the anterior face of the posterior adductor muscle. In front of each is a separate respiratory ganglion (*r g*). From each pleural ganglion a pleuro-visceral connective (*pv*) extends to the corresponding visceral ganglion, and from the cerebral ganglion a very short cerebro-pedal connective (*cp*) to the pedal. I think there is still a distinct pleuro-pedal connective, but this I can not state positively. The ganglia contain the ganglion cells and the connectives contain only nerve fibers.

The kidneys (*k*, fig. 7) consist of large vacuolated cells, and open externally in front of the posterior adductor. The internal pericardial openings I have not been able to find. Lying around the cerebral ganglion is a gland which, so far as known, is peculiar to ship-worms and which, in later stages, becomes so greatly developed in connection with the gills. The glandular portion (*g D*, fig. 24) contains spherical cells, and from it a duct opens to the exterior (*d D*) under the cerebral ganglion.

METAMORPHOSIS.

The duration of the free-swimming life of the larva is not known, but it is perhaps a month, more or less. In a very much shorter period after attachment, the peculiar ship-worm has been developed, with the adult organization essentially completed. The first change is the sudden entire loss of the velum. Within a few hours after the larva has settled, the velum begins to disintegrate and its constituent cells are cast off and eaten by the larva. The lower lip is projected forward under the cavity of the velum, and as the cells are cast off they can not pass to the exterior, and so are eaten. The basement membrane of the velar epithelium contracts rapidly and the cavity of the velum is very quickly obliterated (within a few hours).

Accompanying the loss of the velum, the long byssus thread has been secreted. As soon as the larva is secured by means of the byssus it seeks a place to burrow, and, in preparation for its future life, its whole organization begins to change. The fusion of the two sides of the mantle ventrally progresses rapidly, and within two or three days (fig. 2) only the opening for the foot is left. The siphons elongate rapidly, and very early (within three days) the mantle grows out posteriorly so as to project beyond the shell. The shell grows and changes rapidly after attachment. Within two days the first row of teeth has been formed on the anterior edge of each valve; the greater growth on the ventral edges causes the two valves to gape, to permit the protrusion of the foot in front and the growth of body behind; the knobs have been formed on dorsal and ventral portions; the apophyses have been formed and the retractor muscles of the foot have become attached to them instead of to the umbonal region of the shell. The foot, meanwhile, has become pestle-shaped.

The alimentary canal takes an important part in the general change. The cæcum of the stomach, present in the larva as a rudiment, enlarges very rapidly and, even before woody material has been ingested in quantity, projects as a large vesicle into the foot. In the early stage shown in figure 8 (four days attached, a half millimeter long) it already forms a large part of the visceral mass. As the ingestion

of woody materials progresses, the cæcum projects more and more posteriorly, and in specimens 2 mm. long (fig. 9) extends much beyond the posterior adductor muscle. The gills soon grow around the foot posteriorly, and in specimens 2 mm. long, 10 to 12 days old, project much beyond the visceral mass (fig. 9). This same stage also shows the pericardial space, with its contained and associated structures, in the position which it occupies in the adult, distinctly posterior to the larger adductor. And in this, as in subsequent stages, the visceral ganglion lies at the posterior end of the pericardial cavity.

There are a number of features in the organization and metamorphosis of the larva that seem to have a wider significance. One of these is the sudden and complete loss of the velum. Lovén thought that, in forms of lamellibranchs studied by him, it entered into the formation of the labial palps. These structures are present in the adult *X. gouldi* only as the small ridges on the sides of a slight groove around the mouth; so that this form, in which they may be said to be absent, does not give evidence necessarily against the derivation of the palps of the adult from the velum of the larva in forms in which the palps are well developed. The velum in various lamellibranch larvæ, however, is very much larger than the palps in early stages, so that most of it must be cast off or absorbed. In the newly attached oyster I have observed that the cells of the velum are absorbed more slowly, though the palps are developed somewhat later merely as ridges at the sides of the mouth. The evidence from *X. gouldi* and *Ostrea virginiana*, it seems to me, shows conclusively that the palps are not derived from the velum. The loss of the velum is an event not confined to the lamellibranchs. Wilson (1890) has observed that the trochal cells of *Polygordius* are suddenly cast off and eaten, as in *X. gouldi*, and Pruvot has described the loss of the test in *Dondersia*. These all seem to be phases of one and the same phenomenon and indicate that the loss of a part of the ectodermal covering during metamorphosis in these and many other forms is a very primitive and general occurrence.

The addition of the ship-worms to the forms which have heretofore been known to possess a byssus apparatus indicates that this structure is perhaps universal in lamellibranch larvæ, though in the adult it may become degenerate. I may add that in *Ostrea virginiana* a byssus apparatus is present in the newly attached larvæ, though here a secretion is thrown out for the attachment of the left valve and does not form a byssus thread. In forms like *Teredo* and *Ostrea* the byssus serves for the attachment of the young bivalves, and apparently it has the same purpose in other forms in which it is present in the young (e. g., *Pecten*) but is lost in the adult. In *Sphærium* and allied forms it serves to attach the viviparous larva to the wall of the brood chamber in the gill of the mother. All the known facts go to show that the byssus apparatus was developed to assist in the transformation of the free-swimming pelagic larva into the lamellibranch with an attached or other settled mode of life. Then, this transformation having taken place, the byssus may be lost, or it may be retained in forms which are permanently attached but lack other means than the byssus for attachment.

The sheath of the crystalline style is well developed in the newly attached larva. Everything, however, indicates its derivation by transformation of the posterior end of the stomach. If we imagine the intestine leaving the blind end of the

sheath, we get an arrangement very like that in *Nucula* and *Yoldia,* in which the posterior half of the stomach has the same structure and function as the sheath in other forms, though no style is formed. Having left, in the development of more specialized forms, its point of origin in the median position at the extreme posterior end of the stomach, the intestine has remained attached to various parts of the sheath of the style, as in *Cardium*, and has reached its greatest displacement in forms like *Teredo* and *Pholas*, in which it leaves the stomach from one side and in which the sheath of the style forms a large blind pouch. If this view of the relations of the stomach, intestine, and sheath be the correct one, then the sheath is not a structure which has been acquired in the more highly specialized forms. It is homologous with the posterior part of the stomach of primitive forms like *Nucula* and *Yoldia*. The intestine has left its original median attachment to the posterior end of the stomach and has become attached to one side of it.

THE ADULT.

After the preceding description of the larva and its metamorphosis, the general plan of organization of the adult ship-worm will be easily understood. This is illustrated for *Xylotrya* in figures 5, 6, 10. Figure 5 represents a left view of a young specimen 4 inches long, as it is taken from its tube. At the anterior end (on the left) the "head" is covered by the small shell, over whose dorsal and posterior portions duplicatures (the "cephalic hood") of the mantle project. Behind the shell extends the long, naked body, tapering so that the whole "worm" forms a very long truncated cone. At the posterior end are shown the points of attachment to the calcareous tube, and from it project the palettes and siphons. From the anterior end, between the gaping shell valves, projects the pestle-shaped foot.

The outer wall of the naked, projecting part of the body is the mantle. If it is removed, as represented in figure 6, the long gills are exposed posteriorly and the large visceral mass anteriorly. The latter is continuous with the foot and extends about two-fifths of the length of the body. It contains the viscera (alimentary canal, genital organs, etc.). Dorsal to it (fig. 10) lies the large pericardial cavity with its contained and associated structures (heart, kidneys, visceral ganglion). Dorsal to the pericardial cavity is the long, narrow anal canal, into which the rectum opens above the posterior adductor muscle, and which is continued into the epibranchial cavity posterior to the visceral ganglion. The shell cavity is occupied mostly by the foot, the cæcum and anterior part of the stomach, and the two adductor muscles which are common to most lamellibranchs.

SHELL.

The newly attached ship-worm larva possesses a typical bivalve shell. The valves are equal in size and united dorsally by a well-developed hinge apparatus. The shell in side view is wider than long; the transverse diameter is about equal to the longitudinal. The right valve (fig. 11) bears three equal hinge teeth; the left, two. Dorsal to the teeth is an external hinge ligament. In each valve the apophysis of later stages is present as a rudiment. Up to this time growth has taken place along concentric lines. From this time on rapid, very unequal growth in different parts

of the valves causes a sudden transformation of the shell, which becomes very different from that of the typical bivalve. The initial stages in this change are shown in figure 14, which is an anterior view of the shell of a ship-worm which has been in the wood a day, more or less. After growing a small amount, the anterior border has cemented to it a row of teeth which have been secreted separately in small pockets in the epithelium of the anterior edge of the mantle. The first row of teeth, as well as those formed through life, are cemented to the shell so as to point almost straight outward and very slightly backward. The apophysis, present as a small rudiment in the larval shell, has grown out into the shell cavity, pushing the mantle before it; and, in this very rapidly attained stage, is almost as large comparatively as in the adult. Meanwhile the ventral edge of the valve has grown rapidly, and there have been formed on the dorsal and ventral portions the two knobs upon which, in this and subsequent stages, the two valves swing during the mechanical process of boring. During these changes the hinge teeth present in the larval shell have disappeared, probably by absorption. The valves which, during larval life, have swung at the hinge so as to open and close the shell cavity on the ventral side, come to swing upon the knobs along a median transverse axis vertical to the main axis of the animal. The greater growth of the valves on their ventral edges causes them to gape before and behind for the protrusion of the foot in front, and the siphons, later the body, behind.

Growth of the valves continues with great rapidity. The left valve of a specimen 1 mm. long is shown in oblique view in figure 15. The chief features that have been introduced are as follows: The point of greatest growth is on the ventral edge. The lines of growth, and hence the rows of teeth, are wider apart on the dorsal half of the anterior border than on the ventral. In this way an angle is formed in the anterior edge, which soon (fig. 16) becomes a right angle. Meanwhile, the posterior border has grown rapidly and flares outward so as to give better purchase for the posterior adductor muscle during its contraction. Likewise, a much smaller portion of the dorsal anterior edge flares outward for the attachment of the anterior adductor (fig. 18).

There is little modification in form, structure, and relations of the shell after the stage shown in figure 16, which is a side view of the left valve from a specimen 5 mm. long. As growth on the ventral edge takes place, the knob is constantly being added to toward the midline and absorbed on the side toward the concavity of the valve. And as growth at the posterior border takes place, the posterior adductor muscle is constantly moving backward. In the larval and subsequent stages, the whole shell, including the teeth, is covered externally by delicate epidermis.

PALLETS.

These structures are peculiar to the ship-worms and have been acquired for closing the outer ends of the burrow against intruders and for other purposes. The structure of one of these is shown in figure 20, which represents the left pallet of a specimen 5 mm. long. It consists of a series of seven funnel-shaped structures which have been formed and cemented, in succession, to the handle. The formation of the pallet is as follows: In specimens still less than 1 mm. long, the mantle

of the posterior region has formed a duplicature (fig. 8, 9), which projects like a collar over the base of the siphons. At the anterior portions of the sides of the space thus formed the epithelium of either side evaginates forward. In the pocket thus formed the handle of the pallet is secreted and projects backward into the "collar" space. The lining walls of the sides of the "collar" space secrete the funnel-shaped pieces which are cemented to the handle. New larger pieces are added in succession at the anterior end, and those first formed may be broken off. In species of *Teredo* the paddle part of the pallet is a solid piece and not divided into a series of pieces, as has just been described for *Xylotrya*. Strictly speaking, the segments of a pallet are semicircular when seen on end. When the two pallets are brought together in closing the outer opening of the cylindrical tube they thus form a truncated cone.

MANTLE AND SIPHONS.

In the adult ship-worm (fig. 5) the mantle forms a very long and very delicate tube, which stretches from the anterior edge of the shell to the base of the siphons. These latter are modifications of the mantle, as in other forms of lamellibranchs. The tube is open only at the anterior end, the pedal opening for the protrusion of the foot; and at the ends of the siphons, the inhalent and exhalent openings. It was formerly a much debated question how much of this tube should be considered body proper and how much siphons. In the light of present knowledge it is easy to see that the muscular collar marks off the end of the body and the beginning of the siphons.

The mantle in ship-worms has undergone more differentiation, perhaps, than in any other lamellibranch. The anterior edge is thickened, as in other forms, and secretes the teeth, the edges of the valves, and the epidermis. The very delicate part underlying the shell, and stretching beyond it to the siphons, secretes the inner layers of the shell and the calcareous tube lining the burrow. Within the shell cavity induplicatures secrete the apophyses, and at the same time absorb part of them as they change shape and position. Also, other parts secrete the two pairs of knobs on the valves. The posterior edge of the shell is not marked by the thickened mantle edge as in other types, but the mantle forms a duplicature around the whole posterior edge of the shell, which stretches forward. On the dorsal side the whole umbonal region of the valves is covered by this duplicature, and to this special part Quatrefages gave the name of "cephalic hood" (*c h*, figs. 9, 26). To it he assigned the function of forming the burrow. It is somewhat, but not very muscular, and no such important work could be done by it. It probably serves as an elastic washer around the "head," which prevents the fine particles of wood grated off by the shell from passing posteriorly to lodge between the mantle and calcareous tube.

In the collar region it has been seen that the mantle forms the duplicature or collar, which projects posteriorly over the base of the siphons, and within the cavity of which the handles and paddles of the palettes are formed separately (fig. 9, 10). The siphons, specializations of the mantle, form two long tubes (fig. 5, 6, 9) whose walls are slightly fused together through half or more of their extent. The anal

or exhalent siphon is without papillæ or tentacles and is shorter and less muscular than the respiratory or inhalent siphon, which bears a number of tentacles (fig. 5, 6, 9). These are sensory structures, but they also serve mechanically to close very quickly the entrance of the respiratory siphon against the entrance of enemies and injurious objects from the outside.

Between the duplicature at the posterior edge of the shell and the collar the mantle is very uniform. Its structure is as follows: Externally, the surface epithelium is composed of flattened, nonciliated cells, which secrete the calcareous lining of the burrow. Internal to the outer epithelium are the weak muscles of the mantle, consisting of the longitudinal layer; a layer in which the fibers cross obliquely to the longitudinal fibers; and internal to these the circular layer. The internal surface of the mantle is lined by cells which in general are columnar and ciliated. Opposite the ends of the gills, the mantle is strongly ciliated and contains numerous mucous gland cells which empty into the internal surface of the mantle cavity. This region is indicated diagrammatically in figures 27–32, where on either side ventral to and outside the ciliated, glandular area the mantle wall is thickened so as to form a groove opposite the groove of the gill. In life these two grooves are in apposition and together form a canal along which the food is swept forward to the mouth by the ciliated cells lining the canal.

Between the two epithelial layers of the mantle there is a reticular network formed of connective tissue, with a small amount of muscle and nerve fibers, etc. The spaces so formed are filled by a peculiar substance whose nature I have not been able to determine. In living specimens the mantle is of a light grayish, translucent appearance. But specimens in alcohol become of almost a chalky whiteness, due to the masses of this peculiar material. Each lacunar space is filled by a more or less spherical nodule, which is just visible to the naked eye. Examined by transmitted light, these nodules are very opaque and seem composed of granular particles; by reflected light they are white. They are insoluble in acids, but soluble in water and quickly disappear in aqueous solutions. Deshayes described them as nonnucleated mucous cells. They are apparently the "siliceous particles" which Hancock observed, and with which he supposed the burrow to be formed. They are not cells, but deposits of some sort. They are probably to be regarded as constituting a reserve of calcium, containing material of some sort for rapid use, as occasion may require, in the formation and thickening of the calcareous tube which lines the burrow.

Special gland of the mantle.—Lying between the two epidermal layers of the mantle, in the middorsal region near the extreme posterior end of the body, there is a small special gland which seems to be peculiar to the ship-worms. The extent and the details of structure of this organ are shown in figure 21, which represents a transverse section of the whole gland in a specimen about a half a centimeter long. The gland consists of numerous more or less spherical, vesicular acini whose average diameter is about a fortieth millimeter. They are lined by flattened, nonciliated, slightly granular cells. From the gland a median duct passes posteriorly to open on the dorsal outer surface.

This gland appears in the young ship-worm soon after attachment as a single median small vesicle of apparently ectodermal derivation. As the animal grows,

new vesicles are formed as outgrowths from those already present. What the function of the gland is has not been determined, but its position indicates that it may be the secretion of some material noxious to enemies that may get into the end of the ship-worm burrow.

MUSCULAR SYSTEM.

Early in this century it was a much debated question whether the muscle then known in the shipworms was homologous with the anterior or the posterior adductor of other lamellibranchs, or with both combined. It was Grobben who established the homology of the muscles when he discovered (1888) the small anterior adductor, which had been overlooked previously.

In the general transformation of the larva into the ship-worm the ligament, which in the larva opposes the two adductor muscles and opens the shell, comes to serve only to keep the two valves from separating from each other. And the two muscles which together, in the larva, oppose the action of the ligament and close the shell come to cause the two valves to swing upon each other on the dorsal and ventral knobs of the shell valves during the process of boring. So the two adductors become antagonistic to each other.

In the newly attached larva both adductor muscles are present, the posterior (*ap*, fig. 7, 22,) already considerably larger than the anterior (*aa*). Both are attached to the valves within the concavity of the shell and well toward the dorsal side. In the general transformation these muscles, as the active mechanical agents in excavating the burrow, undergo considerable change. The posterior adductor, as the one that really does the work, becomes very large (fig. 6, 9, 10) and passes posteriorly to be attached to the outwardly turned edges of the shell (fig. 15–17), so as to give it better purchase during its contraction. The anterior adductor muscle, whose only work is to bring the shell valves back to their original position, after contraction of the posterior adductor, is comparatively very small (fig. 6, 9, 10, *aa*), and moves forward from its original position in the larva to be attached to the outwardly turned anterior edges of the shell valves.

In minute structure all of the muscle fibers of both adductors are apparently striated, due to a more or less regular deposit of granular material on their surface. This structure seems to support the view as to the function of the two parts of the adductor in forms like *Pecten*, where one part is tendinous and is supposed to prevent the shell valves from separating too far. The other part, composed of striated fibers which contract quickly, is for active adduction of the valves. In ship-worms, where it is not necessary to oppose the action of a hinge ligament, all parts of both muscles are of the same character as that part in *Pecten* which is supposed to serve for active adduction.

The pedal muscles in the larva are those typical of lamellibranchs with a foot. A pair of anterior retractors and a pair of protractors of the foot are attached in the anterior umbonal region of the shell valves; and a pair of posterior retractors, in the posterior umbonal region, anterior to the attachment of the posterior adductor muscle. With the remarkable growth of the apophyses of the shell, the posterior retractor muscles suddenly lose their old attachment in the umbonal region, to become attached to the apophyses through almost the whole length of the latter.

After this shifting, which takes place as the young ship-worm begins to bore, these muscles no longer are sharply defined, but form wide bands which run from the apophyses to be distributed around the sides of the foot

In ship-worms the posterior end of the body, which has usually been described as the "muscular collar," contains a number of highly specialized muscles, some of which are peculiar to the ship-worms. Their general arrangement and their relations to the pallets, to the calcareous tube, and to the siphons are shown in figures 35 and 36. They are divided into two sets, those which manipulate the pallets and those which are distributed to the siphons. The first set consists of a pair of protractors of the pallets (*pp*), two pairs of retractors of the pallets (*rp*), and a single adductor of the pallets (*ap*). On each side the protractor of the pallet is inserted along the handle of the pallet, whence it radiates to be attached to the side of the calcareous tube along a broad line, its origin. On each side there are two retractors of the pallet. One is inserted on the end of the handle and passes forward to be distributed in the mantle along the sides of the body. The other is inserted near the outer end of the handle, whence it runs forward to be attached to the wall of the calcareous tube along with the siphonal muscles. The adductor of the pallets is a stout, cylindrical muscle stretching between the anterior ends of the two pallet handles, and lying in the septum which divides the mantle cavity into epi and hypo branchial cavities posteriorly. The muscles of the siphons are attached on each side to a triangular area of the calcareous tube, slightly anterior and ventral to the attachment of the pallet muscles. From this origin the siphonal muscles are distributed to the siphons, mostly to the respiratory.

The action of the muscles of the pallets and siphons is as follows: When the ship-worm is undisturbed, the siphons are widely extended into the water and the pallets are drawn forward, as represented in figure 35. If the animal is disturbed the siphons are retracted with great rapidity by the contraction of their muscles. At the same time, by the action of the protractors of the pallets, the pallets are pushed forcibly into the end of the tube so as completely to close the latter. The outer ends of the paddles are brought together by pushing against the sides of the tube. The pallets are dislodged by the more powerful ventral retractors, and retraction seems to be completed by the long muscles attached to the ends of the handles. At the same time, by the action of the adductor of the pallets, their paddles are separated so as to permit the extension of the siphons by an inflow of blood.

From this description it is seen that the end of the tube of *Teredo* is homologous with the pallial sinus of typical lamellibranchs. The same siphonal muscles are present as in other forms, but the muscles of the pallets are peculiar to the ship-worms.

RESPIRATORY SYSTEM.

The gills of *Teredo* are perhaps more highly specialized than those of any other type of lamellibranch, for they possess a membranous, nonperforate portion which reminds one of the gill structure in the Septibranchia, and they are otherwise sharply marked off from those of forms most nearly related to the ship-worms and of other lamellibranchs.

Development and general structure of the gills.—The embryonic development of the gills of *Teredo* has been observed by Hatschek (1880) in the viviparous larva of the unidentified species he studied. Here the rudimentary gill of each side is a fold in which perforations appear in succession, new ones being added posterior to those already formed. In the newly attached larva of *X. gouldi*, the gills have advanced but little beyond the stage described by Hatschek. On each side there are two slits and the rudiment of a third. The slits, however, have so increased in size as to occupy most of the space on the upper sides of the foot and the gill-fold has fused to the sides of the foot by its ventral edge. In this way, the gill-slits come to separate bars or filaments attached at both ends (fig. 24); and as the fold, when it appears, is attached dorsally along the line of attachment of the mantle on the sides of the body and the ventral edge fuses with the upper part of the foot, the gill-bars or filaments lie almost horizontally in the mantle chamber.

This mode of differentiation of the gill by the formation of gill-slits in a fold whose ventral edge fuses continuously, at first with the sides of the body and visceral mass (fig. 2) and later with its fellow of the opposite side (fig. 3), is kept up during life. Beginning, however, with a stage still less than 1 mm. long, the process is modified as follows: In specimens less than 1 mm. long (fig. 2) the gill of either side consists of a membrane with a single series of gill-slits which decrease in size from before backwards. When, however, there are about fifteen slits in the series, a perforation in the gill-fold or membrane appears opposite and internal to the tenth (rarely ninth or eleventh) slit of the first series. New ones are added in succession posterior to it, so that a second series of slits comes to be formed internal to the first (fig. 3). At the posterior end the slits of the inner series always lag slightly behind those of the external in their development. As shown in figure 3, there are no slits in the inner series internal to the ten first formed in the outer series, and none ever appear, a fact of significance, as will be shown in describing the gill of the adult, where the first formed part of the gill, with its outer series of ten gill-slits, becomes widely separated from the rest of the gill.

The gill-fold and gill in the young *Teredo* represent the *internal half of the molluskan ctenidium.* From the resemblance of the mode of development to that in *Cyclas* (Ziegler) and *Mytilus* (Lacaze-Duthiers), it is seen that the slits of the first formed series separate the descending limbs of the lamellibranch gill filaments, and that the second series separate the ascending limbs. The anterior ten filaments, then, never develop the ascending limbs. Likewise, the other (the outer) half of the ctenidium is never developed in *Teredo*—contrary to the belief of Deshayes and Quatrefages, who believed the whole ctenidium, or "pair" of gills, to be present on either side of the body.

The term "gill-fold" I have used to designate the posterior end or growing point of the gill, and "gill-filaments" the elements that are formed from it. In later stages, however, soon after that shown in figure 2, the growing point forms a more or less cylindrical hollow tube, filled by a blood space, which fuses continuously on the midline with its fellow of the opposite side, and dorsally over a wide area (between the two points indicated in fig. 37) with the mantle. In this way the epibranchial cavity is separated from the rest of the mantle cavity. Meanwhile,

the free portion of the growing point has become angular, and at the sides of the angle the two series of perforations are formed progressively (fig. 3), the outer always slightly in advance of the inner. The corresponding slits of the two series push in (in the direction of the lower arrows in fig. 37) till they meet each other and till they push through to the epibranchial cavity. These in-pushings divide the original blood space of the growing point into flat spaces separated from each other except at two points, the openings into the afferent and efferent branchial veins. The median portion of the original blood space remains undivided as the afferent vein, and by the disappearance of the median part of the walls of the two growing points as they fuse together, the afferent veins of the two sides unite, posterior to the visceral mass, to form the single large, median, afferent branchial vein. The undivided outer dorsal portion persists as the efferent branchial vein on each side. The walls of adjacent slits are connected by numerous connective-tissue cells (fig. 38) so as to form the gill laminæ, the name given to them by Quatrefages and more appropriate for the gill elements in ship-worms which (except the anterior eleven) do not form filaments. From the mode of formation it is seen that there is a large flat blood space in each lamina and that there is a free flow of blood through the lamina (in the direction of the arrows, fig. 37) between the afferent and efferent branchial veins.

In a young ship-worm a half centimeter in length (somewhat later than the stage represented in fig. 3) there is on each side a continuous series of seventy-five or more gill filaments (filaments and laminæ), stretching from the mouth region around the sides of the body and posterior to the visceral mass. Soon afterwards the "filament" between the tenth and eleventh (usually) gill-slits broadens from before backward. This growth increases till, in large specimens of the adult, the anterior eleven filaments (it may rarely be ten or twelve) are separated from the rest of the gill by a space of 10 cm. or more. They retain the structure, however, and doubtless the function, of gill elements, though in the adult they form a series of simple bars attached at both ends on the sides of the "head" (fig. 6). In reality the first and eleventh filaments are but half filaments.

In ship-worms the epibranchial cavity forms a single long canal posteriorly (fig. 10, 31, 32), but is divided anteriorly where the gills of the two sides diverge from each other. As the anterior eleven filaments become separated from the rest of the gill, the epibranchial cavity between these two parts of the gill becomes a long, very narrow canal (*ep ca*, fig. 26–29), which lies in the mantle on each side, external to the afferent branchial vein and adjacent to the groove described below.

The two limbs of a gill lamina (fig. 37) form almost a right angle with each other. At the angle there is a ciliated groove (fig. 30–32, 37) which extends the full length of the gill in young specimens (fig. 3), and in adults, in addition, connects the anterior eleven filaments with the rest of the gill (fig. 6, 26–29). In the adult the connecting part of the groove, then, is really a part of the gill and is homologous with the groove of one filament in other parts of the gill. The minute structure of the groove is as follows: The lining cells are in the main strongly ciliated and columnar (fig. 44), but there are distributed among them numerous mucous gland cells. As already noted, the internal surface of the mantle opposite the edge of the gill

also forms a groove lined by strongly ciliated cells with many mucous gland cells among them, and this, with the groove of the gill, forms a very long tube which conveys food to the mouth.

Minute structure of the gills.—It has been seen that, by their mode of formation, the "intrafilamentar union" between the two limbs of a lamina is so complete that blood may flow freely through the wide, flat blood space of the lamina from the afferent to the efferent branchial vein. The "interfilamentar" or, better, interlaminar connection between adjacent laminæ, is also very extensive, but serves only for support and does not permit the full interchange of blood. The general plan of the interlaminar connections is shown in figure 39, which is a tangential section of a gill almost in the line of the letters *ifj* in figure 38. It is seen that the points of union in adjacent laminæ are arranged in regular rows. At each point the supporting rod (*s r*, fig. 40) projects through a perforation, so as to bind together adjacent laminæ. Attached to adjacent rods are fiber-like cells, which are apparently muscular and contractile.

The minute structure of the edge of a lamina is similar to that of the filaments in forms like *Mytilus*, though the various types of cells are more sharply marked off from each other. At each side there are two rows of large "lateral cells" (*l c*, fig. 40), bearing long, dense cilia. External to these are small nonciliated gland cells, and at the angles the small, flattened "latero-frontal" cells (*lfc*, fig. 40), each with a single row of stiff cilia. The outer edge of the laminæ is occupied by numerous small "frontal cells" (*fc*) which bear numerous weaker cilia. The two broad sides of the lamina are composed of very flat cells without cell outlines or regular arrangement, and are connected together by numerous connective-tissue cells which penetrate the blood space of the lamina (*bs*, fig. 38, 40). In their minute structure (fig. 41) the anterior eleven filaments which are separated from the rest of the gill are essentially like the rest of the gill, except that the "frontal cells" are more numerous, and the middle ones seem to bear no cilia. The first and eleventh filaments are only half filaments, indicating that the filaments are formed by perforations in a gill membrane which is primitive, and not that the membrane is formed by the precocious fusion of gill filaments. The long epibranchial canal is sparsely ciliated, and it seems that the special function of the anterior eleven filaments is to get rid of superfluous water in the anterior end of the burrow.

Glands of Deshayes.—Closely associated with the gills of the adult is a pair of very complicated structures which, so far as known, are peculiar to ship-worms, and which constitute one of the most important features which distinguish the ship-worms from other types of lamellibranchs. In honor of the observer who first called attention to them, I have called them the "glands of Deshayes." Though he pointed them out they have never been fully described as to character, structure, and relations.

Deshayes observed a peculiar structure in the umbonal region on each side of the shell cavity. He described it as of glandular nature and supposed its function to be the secretion of a fluid to soften wood in the formation of the burrow. In the gill laminæ he described peculiar modifications of the tissues, which he supposed to be mucous glands and to serve for the nutrition of the viviparous embryos of ship-worms. He also described a third structure as invading a part of the walls of

the afferent branchial vein, and of unknown function. These three glands described by Deshayes are parts of one and the same structure, which is present, in different degrees of development, in all of the three species I have studied. In all three the part in the gill is well developed. In *T. dilatata* the umbonal portion of the gland is so large as to occupy a considerable part of the umbonal region of the shell cavity; in *X. gouldi* it is small, and in *T. navalis* apparently rudimentary. In his studies of the pericardial glands in lamellibranchs, Grobben sought in *Teredo* for the gland described by Deshayes in the umbonal region, thinking it might represent a part of the pericardial gland of other forms which possess this organ. He failed to find it and supposed it to be absent. However, though he apparently had none of the forms with which I have worked, I think it was doubtless present in his species.

In the larva this peculiar structure is present on each side in front of the cerebral ganglion, though still comparatively simple (*g D*, fig. 7). It is vesicular and filled with spherical *cells* of apparently mucous nature. A duct leads to the exterior, opening at the side of the mouth on the ventral side of the velum.

The structure of subsequent stages of the gland will be best understood by first describing that part in the gill. An examination of figure 38 will show that this modified portion contains elements of two very different types of structure. Their distribution and relations are best shown in figure 37, which represents a lamina from the gill of *T. navalis*, in which species they are most strikingly developed. This figure also shows the distribution of the gland in the branchial vein, and that this portion is of the same nature as that lying in the lamina adjacent to it. Still farther from the vein is the second type of structure. Ramifying in all directions from the latter are dentritic processes which penetrate the epithelial walls of the lamina. These ramified portions are the primary structures, apparently, and the other two are derived from them. The structure of the dentritic portion is shown in figures 46 and 47, which were drawn under a magnification of 1,900 diameters. The processes seem devoid of any membrane. The contents consist of very minute filamentous structures arranged lengthwise in the direction of the process. Lying in the mass thus formed are nuclei which vary in number and position. The middle one in figure 48 indicates that they may change position, and that the whole structure forms a syncytium. The enlarged portions of the processes, shown in figure 37, become surrounded by a specialized epithelial covering, apparently derived from the lining cells of the gill lamina. This stage is represented in figures 46 and 47. The minute filamentous structures have taken on a more irregular arrangement, and lying within the mass are spherical cells of varying appearance. While some (fig. 45) are coarsely granular, others are almost homogeneous. The nuclei lie on one side of the cells.

The other type of structure (fig. 49–51) I am confident, though not perfectly sure, is also derived from the dentritic processes along with a modification of the surrounding epithelium. The developed structure is of remarkable appearance (fig. 51). The base is composed of modified epithelium cells of the wall of the lamina. The nuclei stain lightly and lie in a granular protoplasm, from which deeply staining rods project toward the blood space of the gill lamina, but from which they are separated by a membrane formed of very flat cells. The development of this structure seems to be as follows: When the dentritic processes penetrate

among the epithelial cells (fig. 48), the filaments are arranged lengthwise; soon they take on a vertical position (fig. 49), enlarge, and become covered by the caplike membrane (fig. 49–51). If this derivation be the correct one, then the rods in figure 51 have been formed by the enlargement of the filaments of the dentritic structures. In the lamina the rods project toward the blood space; in the afferent branchial vein, away from the blood space. Why the difference I do not know.

The development of the gland of the adult, so far as I can determine, is as follows: When the small ship-worm has been in the wood for a day or so, the gland of the larva sends out processes which invade the surrounding ectodermal tissues (the mantle, sides of the body). As the side of the body becomes enlarged, it fuses with the dorsal sides of the gill filaments (fig. 25). From the first there is close association between the gland and the gill. As the latter grows, the filaments become invaded by the gland; and, as the anterior ten filaments become separated from the rest of the gill, the two parts of the gland thus differentiated remain connected by a long, narrow duct which accompanies the epibranchial canal and lies in the afferent branchial vein (fig. 26–30). With the separation of the two parts of the gill, the intervening part of the gland disappears in *X. gouldi* and *T. navalis*, but persists in *T. dilatata*. As the gland enters each gill lamina, it remains connected by a small duct with the main duct, and may send the granular cells into the latter. The main duct may become gorged with granular cells (fig. 37). In most cases, however, there are few cells in it, and I am inclined to regard the main duct (at least in *X. gouldi*) as degenerate and perhaps essentially functionless. Likewise, I am inclined to regard the formation of the spherical cells in the one part as not the chief function of this part of the gland. The origin and fate of the cells I have not been able to determine. Their contents suggest that they may be modified mucous gland cells.

What the special function of this remarkable structure is I am not able even to guess. The rudimentary character of the anterior part in the "head" of *T. navalis* indicates that it can not be the formation of a secretion to soften wood. Its development in the gill, in small as well as large individuals, in male and female, and in forms that do not retain the eggs in the gills, proves that this part can not be for the nutrition of viviparous embryos. The close connection with the gill indicates, it seems to me, that its function may be the elaboration of some internal secretion or other material for whose formation the presence of both blood and water is necessary.

CIRCULATORY SYSTEM.

The circulatory system of the shipworms is highly modified in relation to the peculiar form of the body. The growth of the visceral mass ventrally at first, and afterwards its great elongation posteriorly, along with the elongation of the rest of the body, accounts for the changes that have taken place. Doubtless the ancestors of ship-worms were lamellibranchs with typical circulation, in which on either side in the pericardial cavity lay an auricle lateral to, and emptying into, the median ventricle which surrounded the intestine; and from the ventricle the anterior aorta passed forward above the intestine and the posterior aorta backward below the intestine. In ship-worms the pericardial cavity, with its contained parts, has come

to lie on the morphological ventral side of the intestine, though apparently on its dorsal side, and the relations of the various parts of the circulatory system to each other and of the system as a whole to associated parts have been radically changed.

The youngest stage of the circulatory system I have observed in detail is in specimens 2 mm. long, in which the heart consists of two almost completely separated halves (fig. 52). On each side a more or less spherical auricle (*au*) lies lateral and slightly ventral to, and leads into, a more or less spherical half of the ventricle (*ve*). Each half of the ventricle sends a very narrow, vessel-like portion toward the midline, where the two sides unite. In this middle portion there are two semilunar valves (fig. 55) on the dorsal and ventral sides, and from this point two vessels emerge. One runs anteriorly, and, bending around the posterior adductor muscle, is continued posteriorly in the mantle. At this stage the visceral mass has projected but little posteriorly (fig. 3), and the second vessel from the heart, somewhat smaller than the other, runs ventrally into the visceral mass. These structures are shown in section in figure 54, which is of a longitudinal section through the median part of the ventricles and aortæ in a specimen 4 mm. long.

In the stage in which the heart is developing the stomach and cæcum already occupy most of the visceral mass and the gills are very wide apart. This may account for the wide separation of the two halves of the heart. In development posteriorly the gills advance ahead of the other structures and, accompanying them, the two sides of the heart are drawn out backward so as to lie side by side. In the adult (fig. 53) the two halves of the ventricle (*ve*) have fused on the midline, except at the posterior end, where the two sides still project as somewhat hemispherical masses. Internally, however, the lumen remains divided (fig. 29) through half of the extent of the ventricles. At the anterior end the ventricle has the shape of an elongated cone. The two auricles accompany the gills in the posterior development of the latter and come to lie side by side like two large vessels in the posterior half of the pericardial cavity. Each projects into the ventricle on its own side and valves separate the cavities of the auricles from that of the ventricle (fig. 53).

The pericardial cavity of the ship-worms (fig. 10, 29, 30) lies on the apparent dorsal, but really on the morphological ventral, side of the visceral mass. It is very large, extending from the posterior adductor to the visceral ganglion through a quarter of the length of the animal. In *Xylotrya gouldi* it narrows in front to form a canal which projects beyond the wider part to the posterior adductor muscle. About two-thirds of the distance from the visceral ganglion to the posterior adductor (fig. 10) the anterior end of the ventricle dips down through the pericardium into the visceral mass. This point is the end of the ventricle and the beginning of the aortæ, the end of the ventricle being marked off by two semilunar valves which project forward on its dorsal and ventral sides (*val*, fig. 55). From the end of the ventricle two vessels are given off. The larger (*avp*, fig. 10, 56) runs forward (fig. 26–28) in the visceral mass and passes ventral to and in front of the posterior adductor, to bend over the latter and enter the mantle as the large dorsal or posterior pallial artery. This runs posteriorly as a single vessel in *Xylotrya*, at the right side of the anal canal and epibranchial cavity (fig. 26–32, *da*) to the posterior end of the body, where it divides into the two paired arteries of the siphons.

This aorta I have just described is the morphological posterior aorta, though its course at first is anterior. The second aorta leaving the ventricle runs posteriorly in the visceral mass, which it supplies, and is the morphological anterior aorta.

The venous system consists of three important parts. Blood from the viscera and anterior part of the body is gathered into a system of afferent branchial veins consisting anteriorly of a pair of large vessels (*ba*, fig. 27–29) which in the region of the visceral ganglion unite to form the single very large afferent branchial vein that runs between the fused gills (fig. 10, 30–32). Passing from this vein through the gill lamellæ, the aerated blood enters the large paired efferent branchial veins, from which it passes to the auricles. Blood from the posterior part of the body is gathered into an afferent renal vein (*arv*, fig. 31, 32), which runs forward and enters the perinephridial spaces at the posterior end of the kidneys.

The description I have just given applies specially to *X. gouldi* and *T. navalis*. In *T. dilatata*, while the relations are somewhat different, the homologies remain the same. In this species the principal part of the visceral mass has remained more anterior and the posterior part of the body is longer in proportion. In following the gills the heart has become much more elongated, and this elongation has taken place principally in the aorta-like part of the ventricle which runs forward from the more thickened portion of the ventricle. In this species the pericardial cavity extends much farther forward than in *X. gouldi*, passing under and anterior to the posterior adductor muscle as a long canal to end under the œsophagus. In this canal the ventricle runs to the anterior side of the posterior adductor and then dips into the visceral mass. Valves mark the anterior end of the very long ventricle, from which two vessels pass forward. The larger, after giving off branches in its course, bends around the adductor and divides into paired pallial arteries which supply the posterior part of the body. This is the posterior aorta. The other, the anterior aorta, also runs forward a short distance, but soon breaks up into arteries which supply the visceral mass.

I have gone into details in describing the aortæ, because the posterior aorta has been described as fused with the anterior in *Teredo*. This observation was first made by Grobben (1888) who described as aorta a part of the ventricle which is distinctly muscular and contractile. The parts which should have been described as aortæ he has not figured at all. Menegaux has also maintained that the two aortæ are fused (1889). Unfortunately neither of these authors names the species with which he worked, but their descriptions of other parts are faulty and indicate that there is little doubt that they have been in error in this regard also.

ALIMENTARY CANAL.

In adaptation to their burrowing mode of life, the alimentary canal of all the Pholadacea has become more highly specialized, perhaps, than in any other type of lamellibranch. This specialization is most accentuated in the ship-worms, apparently in association with the ingestion of the particles of the wood grated off in burrowing.

Most of the parts of the alimentary canal of the adult are already present in the newly attached larva, though their relations to each other and their relative

development are very different from the adult condition. The general plan is shown in figure 7, which represents a newly attached larva from the right side, with the shell, mantle, and gills removed. A long, ciliated œsophagus (fig. 7, 22 *oe*) leads into a rather small stomach, from which projects on each side a large, simple, almost spherical liver lobule. The wall of the liver is composed of large, coarsely granular, pigmented, nonciliated cells (fig. 7, 23). The intestine leaves the right side of the stomach (fig. 7, 24) and after forming a single loop passes over the posterior adductor muscle as the rectum. Just posterior to the point of origin of the intestine is a small hemispherical diverticulum of the stomach, the cæcum (*ce*, fig. 7, 23, 24), composed of densely granular, nonciliated cells. The posterior ventral part of the stomach is occupied by the opening of a large conical diverticulum, which is median in position, the sheath of the crystalline style (*s s*, fig. 7, 22). Its walls are composed of large, coarsely granular, densely ciliated cells characteristic of this structure, except at the blind end, where the cells are smaller, more finely granular, and nonciliated (fig. 22).

The alimentary canal of the larva is interesting because of the advanced development of some parts and the retarded development of others. The liver has advanced but little in form beyond a stage reached two or three days after hatching. On the other hand, the cæcum of the stomach, which is peculiar to the members of the Pholadacea, is already present as a rudiment, although it is not to become functional till after the adoption of the burrowing mode of life in the wood.

As the larva develops into the ship-worm, the size and relations of the parts of the alimentary canal change greatly. The œsophagus becomes, in the adult, very short in comparison with other parts (fig. 10). The stomach elongates posteriorly more and more (fig. 8, 9, *s*) till, in the adult, it projects far beyond the posterior adductor muscle and forms a long, irregular, more or less cylindrical tube (fig. 10). As is well known, the wood grated away in boring is ingested and stored in the cæcum of the stomach. Even before the ingestion of the wood begins, the cæcum projects into the foot as a large hollow vesicle lined by clear, ciliated cells; but as soon as wood is ingested it enlarges rapidly and soon forms the largest part of the digestive system (fig. 8, 9, 10, *ce*). With its increase in size, it comes to leave the posterior end of the stomach and crowds the sheath of the crystalline style to the left side (fig. 8, 9, 10). In young specimens the cæcum occupies almost the whole mass of the foot, and its blind end points forward (fig. 8, 9). As the visceral mass elongates, the cæcum is gradually drawn backward, till in the adult it forms a very long cylindrical tube, stretching to the posterior end of the visceral mass (fig. 10, *ce*). In ship-worms that are boring and growing the cæcum is always completely filled with ingested particles of wood. The scarcity of diatoms and other food materials seems to indicate that in the ship-worm boring an ingestion of wood alternates with ingestion of food, and that in feeding the food is guided into the intestines, and in boring the particles of wood into the cæcum. The cæcum of the adult is, then, a long blind tube, opening only at its anterior end into the stomach. Internally it is lined with a ciliated mucous membrane, which is infolded on the ventral side like a complex typhlosole (fig. 30, 31). This fold

seems of independent origin, and not at all homologous with the fold in the intestine. The long retention of woody particles in the cæcum, along with the greatly increased absorbent surface of the latter, indicates that the wood is at least in part digested and serves as food.

In elongating posteriorly, the cæcum pushes the intestine ahead of it, so that the latter always forms a very long loop around the posterior end of it. In the adult the intestine, because of the great development of the cæcum and the greater development of the liver on the right side, leaves the stomach slightly to the left of the midline, near the posterior end (fig. 10). Bending forward it forms a single short loop and then passes backward to form the loop around the cæcum. Then passing forward dorsal to the stomach it bends over the posterior adductor as the rectum (*r*), which projects slightly into the anal canal. Throughout its whole extent the intestine possesses a typhlosole, but slightly developed except in that part next to the stomach. Here it is so greatly developed as to form several coils (fig. 27), which are analogous to the spiral valve of the intestine of elasmobranchs. Because of this the diameter of the intestine in this region is greatly enlarged (fig. 10). The intestine of *X. gouldi* is very much shorter than in other shipworms. This shortening is doubtless connected with the greatly increased absorbent surface because of the coiled typhlosole. In most shipworms the intestine forms several coils before it passes around the cæcum, and in such forms there is no greatly developed typhlosole.

In ship-worms, as in *Pholas*, there is a second small, quill-shaped cæcum of the stomach on the dorsal side to the left, under the posterior adductor muscle (*ce'*, fig. 9, 10, 26). It is lined by columnar, ciliated cells and generally contains particles of sand. It is small and seems rudimentary, but it may have some function unknown at the present time. Pelseneer has observed an apparently homologous structure in *Nucula*, where it is said to secrete a small style.

The sheath of the crystalline style, present on the midline of the larva, comes to arise from the left side of the stomach near the anterior end of the latter (*ss*, fig. 9, 10), and hangs toward the right side. Its blind end forms a vermiform tube, which is very different from the rest of the sheath. The latter has its walls composed of large, coarsely granular cells, which bear long, very heavy, dense cilia (fig. 56). The tubular portion, on the other hand, has its walls composed of elongated, densely granular and deeply staining, nonciliated cells. In adults the walls of the tube may become very thin (fig. 57), in parts. What the function of this tubular portion is I am not able to state, though it is perhaps the secretion of some constituent of the style. Barrois (1889) has figured a *pair* of diverticula at the ends of the sheath of *Pholas dactylus*, lined by cells similar to those of the rest of the sheath. On examining sections of specimens of *Pholas* of apparently the same species as those studied by Barrois I find a single tube, as in ship-worms, lined by cells of the same character as in the latter. I am inclined to believe that Barrois's description and figures are faulty.

The liver, composed of a single spherical lobule on either side of the stomach in the larva, soon divides into several lobules on either side (*l*, fig. 8, 9). As growth takes place, the duct of the right half of the liver divides (in specimens 4–5 mm. long) and as the shipworm elongates, the posterior part of the right half of the

liver passes backward, so that in the adult its duct opens into the posterior end of the stomach. These anterior and posterior portions of the liver are completely separated from each other, forming separate liver masses (fig. 10). The anterior remains in the foot and sends its duct to open into the lateral anterior portion of the stomach. There seems little doubt that it was this part which Frey and Leuckart observed and described as the salivary glands peculiar to ship-worms. The posterior part of the liver is the larger of the two and opens by a very large duct into the ventral part of the stomach. It is differentiated into two portions, which in structure and apparently in function are quite distinct from each other, though they open into the stomach by the same duct. The more elongated, slightly larger portion (fig. 28) lies on the right side, and in structure is like the anterior liver mass of ship-worms and the whole liver in other forms of lamellibranchs. The second portion (fig. 28), lying more on the left side, is different in appearance. Its lobules are larger, with larger lumens and thinner walls, which are composed of flattened cells glandular in appearance. The presence of large quantities of woody materials in these larger, thin-walled lobules suggests that this portion of the liver may be specialized for the digestion of cellulose, and this view is strengthened by the long retention of woody materials in the cæcum. This portion of the liver is adjacent to the opening of the cæcum, and it may be that it secretes a ferment for cellulose digestion which is continued in the cæcum. As has been pointed out already, the latter by its structure seems adapted to absorption on a large scale.

NERVOUS SYSTEM.

The nervous system of ship-worms I have studied in the larval and subsequent stages to the adult of *Xylotrya gouldi*, and in the adult of *T. navalis* and *T. dilatata*. While my description applies especially to the first of these, the others are in such close agreement that we seem justified in believing that there is great uniformity in this regard in all of the species of the Teredinidæ, and that the descriptions heretofore given have been somewhat erroneous.

Nervous system of the larva.—In the newly attached larva the principal elements of the adult nervous system are present. In their relations to each other, however, the embryonic development of these is not complete; and in their relation to other structures great changes take place along with the change in the general organization. The general plan is shown in figures 7 and 59, the latter representing a dorsal view of the nervous system of a larva just attached. In front of and on the sides of the mouth are the two cerebral ganglia (*c*), separated from each other by a very short commissure, and each sending a connective to the pedal ganglion (*p*) of the same side. Lateral to the cerebral ganglion of each side is the pleural ganglion, still distinctly separate from it and sending a connective posteriorly to the visceral ganglion. I think there is also a pleuro-pedal connective at this stage, but this I am not able to state positively. The two pedal ganglia are as completely fused together as in the adult, and lie just posterior to the beginning of the œsophagus (fig. 22). Lying immediately in front of the posterior adductor muscle (fig. 7, 22, 24), the two visceral ganglia together form a long cylinder enlarged at both ends. The commissure connecting the two ganglia contains ganglion cells. The two sides rapidly become more closely fused and, in the early stage represented

in figure 8, the concentration is almost as great as in the adult. Each visceral ganglion of the larva gives off a respiratory nerve which bears a respiratory ganglion still far apart from the visceral. While the visceral ganglia are becoming more closely fused, the commissures between the cerebral and pleural ganglia are becoming obliterated. The pleural ganglia persist as separate masses in the young ship-worm of three or four days (fig. 8), but soon afterwards fuse completely with the cerebral, though sections of later stages still indicate by their structure the double origin of the so-called cerebral ganglia.

While these concentrations of the visceral ganglia with each other and of the pleural with the cerebral have been taking place, the cerebral commissure is constantly elongating, along with the growth of the œsophagus, so that in the adult the cerebral ganglia are separated from each other by a comparatively long commissure.

Nervous system of the adult.—Along with the great change in the general relations of the various systems that has taken place during the transformation from the larva to the adult ship-worm, the nervous system has changed principally in the altered position of the visceral ganglia, which lose their place in front of the posterior adductor muscle, and come to lie much posterior to it. The same three pairs of ganglia are present in the ship-worms, however, as in other types of lamellibranchs. The general arrangement is shown in figure 60. Lying almost at the sides of the mouth are the two cerebral ganglia (*c*, fig. 10, 60), well developed and separated from each other by a long commissure (*c c*), which is composed only of nerve fibers. From near the outer end of each a single large pallial nerve passes, to be distributed to the parts of the mantle which underlie the shell and form the cephalic hood. From near the inner ends of the ganglia large connectives pass around the sides of the mouth to the pedal ganglia (*p*); and from the posterior outer ends the cerebro-visceral connectives pass posteriorly to the visceral ganglia. The pedal ganglia give off several pairs of large nerves to the foot.

Visceral ganglia.—The two visceral ganglia of the larva fuse into the single mass which lies very far posteriorly in the adult (*v*, fig. 10, 60). After leaving the cerebro-pleural ganglia, the cerebro-visceral connectives pass along the sides of the "head" under the anterior gill filaments; but posterior to the large adductor muscle they take up a more median position, among the tissues of the liver and reproductive organs. In front of the visceral ganglia they come to lie close together, internal to the large, ductlike portions of the reproductive organs. But before entering the visceral ganglia, they pass dorsal to a small "anterior ganglion" which lies just in front of the latter. In passing through they give to it a small number of nerve fibers (fig. 63), which are lost in it. Then the connectives enter the visceral ganglion but little diminished in size. This anterior ganglion was first described by Pelseneer (1888) for the ship-worms, and seems peculiar to them and their allies. It is a small ganglionic mass lying distinctly in front of the visceral ganglion in well-preserved specimens. From the fact that fibers cross between the sides, it seems composed of two halves, quite completely fused together. As has been stated, the cerebro-visceral connectives in passing send fibers ventrally into it, to be completely lost there. From this ganglion several pairs of nerves are

given off which innervate the kidneys and other viscera, the genital papillæ and the osphradium, at least in part (fig. 60). From the anterior end a pair passes forward to supply the genital organs and perhaps other viscera. From the middle of the ganglion a pair passes laterally to innervate the genital papillæ and the kidneys (fig. 63). Leaving the posterior lateral angles of the ganglion, the largest pair of nerves pass backward under the visceral, and divide each into two parts. The one, somewhat larger than the other, passes dorsally to enter and be lost in the mass of the visceral ganglion. The other passes laterally to innervate the osphradium.

The visceral ganglion proper of the adult (fig. 10, 60), because of the great development of the posterior part of the body innervated by it, has attained greater comparative size than the cerebral and pedal. It forms a somewhat three-lobed mass, in which the larger central part consists of the completely fused pair of visceral ganglia of the larva, while the lobe on either side consists of the respiratory ganglia of young stages which have come to lie adjacent to the visceral proper.

From the visceral ganglion several pairs of nerves are given off, whose connection with the visceral is through the lateral masses (fig. 60). Passing forward on either side are two small nerves (fig. 60, 1 and 2) which accompany the kidneys and anal canal and innervate the posterior adductor muscle and the mantle anteriorly. Given off slightly posterior to them, a large nerve (3) goes directly to the middle part of the mantle. Posteriorly, a pair of large pallial nerves (*pn*, fig. 31–33, 60) passes backward to innervate the posterior part of the mantle, including the siphons and the muscles of the palettes. The branchial nerves (fig. 60, *bn*) pass laterally, closely associated with the osphradium, and then innervate the gills.

This description of the nervous system differs essentially from that of Quatrefages (1849) which has heretofore been accepted. He thought the two cerebral ganglia closely fused, and the pedal rudimentary and separate. I have no doubt that he mistook the pedal ganglia for the cerebral; his figures seem to show this. But what he observed and figured as the two very small pedal ganglia I do not know. It has been seen that while the pedal ganglia are not so large as in forms with a large foot, they are not at all rudimentary.

Otolithic vesicles.—The larva leads an active, free-swimming life, and some means of orientation is very essential. This is the function of a pair of otolithic vesicles in the usual position in the foot. But the adult ship-worm may assume any position and the otolithic vesicles become useless and degenerate. After attachment they soon cease to grow and, in specimens 2 or 3 mm. long, their function seems lost. They persist as small masses of cells in the adult, though without a lumen and without the otolithic concretions.

Sense organ of the genital papilla.—One of the pairs of nerves of the anterior ganglion has been described as going to the kidneys and genital papillæ. Situated just at the junction of the ectodermal genital duct with the sexual organ there is an organ which, by its structure, seems to be for special sensation. The nerve to it (fig. 63, 64), after a very short course, is distributed to sensory cells which lie adjacent to the epithelial lining of the genital duct. The sensory cells are long spindle-shaped, and send their peripheral ends to terminate among the epithelial cells lining the

genital duct. Their central ends I have not traced distinctly into the nerve to the anterior ganglion, but it seems justifiable to suppose that this is their connection. What the function of this organ is I can not state. While the figures apparently show it some distance from the exterior, it should be remembered that, in ship-worms 30 mm. long, the sexual duct is less than a half millimeter long, and that the sense organ is really very near to and, for purposes of sensation, practically at the surface.

Osphradia.—In the ship-worm these molluskan organs of special sense form large masses of complex tissues at either side of the visceral ganglion (fig. 60). Their general shape is elliptical and they are in close association with the branchial nerves. Each organ (fig. 65) is composed of two parts. At the ventral (outer) surface there is a part of the body epithelium, which in this region is specially differentiated from the surrounding cells. While the epithelium of the epibranchial cavity is ciliated, the osphradial epithelium is quite devoid of cilia. Besides, the cells composing the osphradial epithelium seem to have quite lost their cell walls, so that the spherical nuclei lie in a common mass of protoplasm. The outer surface of the epithelial layer is covered by a very delicate membrane, and at its internal surface there is a stouter basal membrane. Underlying the surface epithelium is a mass of nervous elements, composed of both cells and nerve fibers. The cells, however, are sensory and stain somewhat differently from the ordinary ganglion cells. They are of two kinds, both spindle-shaped, and sending their peripheral ends through the basement membrane of the overlying epithelium, to break up into brushlike terminations just inside the delicate outer membrane of the epithelium. These structures are shown in figures 65 and 66. In figure 65 both types of cells are shown, the larger one to the left representing the type much less numerous than the other, staining differently from them, and penetrating the osphradial mass to terminate centrally differently from the smaller, more numerous cells. The internal or central connections I have not been able to determine, but this much it seems justifiable to state: The osphradial nerve from the anterior ganglion becomes so closely associated with the respiratory nerve that it can not be stated that the anterior ganglion alone supplies the osphradium. Also, the large sensory cells penetrate through the osphradial mass, and especially it can not be stated that their connection is with the osphradial nerve.

These structures I have described in some detail for two reasons. In the first place, the epithelium of the osphradium is usually described as consisting of columnar cells, which form the sensory part of the structure. This I have found to consist of a layer in which cell outlines are not distinguishable, and in which the spherical nuclei lie as in syncytium. The real sensory cells are the spindle-shaped cells lying in the deeper part of the osphradium.

In the second place, Pelseneer (1891) has described the osphradium in ship-worms and *Pholas* as innervated by a nerve from the anterior ganglion, and the latter as connected with the cerebral ganglia through the connectives. From this he concludes that the osphradia, as well as the other organs of special sense, are innervated from the cerebral ganglia. The organization of the nervous system in ship-worms, it seems to me, lends no evidence whatever to this view. The nerve fibers received from the connectives by the anterior ganglion are quite lost in the latter, and can not be traced into any of the nerves which leave it. Moreover, the anterior ganglion may, with much more reason, be said to be connected with the visceral ganglion, for

the branch of the so-called osphradial nerve from the visceral ganglion to the anterior ganglion is much larger than the nervous elements received by the anterior ganglion from the cerebro-visceral connectives. Pelseneer seems not to have seen the other nerves that leave the anterior ganglion. With as much reason it might be said that the structures they supply also are innervated from the cerebral ganglia. Nerve fibers, it may be, pass from these structures through the anterior ganglion to the cerebral, but that the latter are the only centers in which reflexes may be established seems not in accordance with the structure of the nervous system in *Teredo*. It seems more plausible to regard the anterior ganglion as a part of the visceral which has been separated from the latter. It receives a part of the cerebro-visceral connective, and gives off some of the nerves that formerly were given off by the visceral.

From a theoretical standpoint, too, one would expect elongated forms like *Teredo* and *Pholas* to have a more direct connection between the osphradia and the reflex centers. If the osphradia test the character of the water flowing over the gills, then it is difficult to believe that in a large ship-worm the nervous impulse should travel from them to the cerebral ganglia and back again through the visceral ganglion to the pallial nerves before the siphons can be contracted and the inhalent current stopped. This would necessitate a course of almost two meters in very large specimens. The more direct connection through the visceral ganglion is the one it seems reasonable to expect.

KIDNEYS.

The kidneys (organs of Bojanus, nephridia) of *Teredo* were observed, apparently, by Deshayes, but mistaken for veins. Quatrefages also observed them, but gave no adequate description. Pelseneer (1891) has noted the position and relations of the openings of the two ducts.

In the adult ship-worm the paired kidneys lie on the dorsal side of the large pericardial cavity and ventral to the anal canal, extending through the long distance between the posterior adductor muscle and the visceral ganglion. Each kidney consists of what may be termed the body, which lies around the posterior face of the posterior adductor muscle (*k*, fig. 10), and two very long ducts, one of which puts the body of the kidney in communication with the pericardial cavity, while the other leads to the exterior. The body is a massive, much pouched structure, in which the lining secretory epithelium is vacuolated and in part ciliated. From the body the very long, narrow, cylindrical afferent duct passes posteriorly (*ka*, fig. 27–29) near the midline. Just in front of the visceral ganglion it enlarges, becomes convoluted internally, diverges from its fellow of the opposite side (*k a*, fig. 62), and dips under the end of the efferent duct (fig. 61) to open into the posterior angles of the pericardial cavity (fig. 30) by a large funnel-shaped opening. The lining cells of the afferent duct are not vacuolated and apparently not excretory; and not ciliated except in the enlarged, funnel-shaped portion, in which they bear strikingly long, dense cilia (fig. 64).

The efferent duct, leading from the body of the kidney to the exterior, is also a cylindrical tube, of much larger diameter than the afferent duct. It runs with the latter near the midline (*ke*, fig. 10, 27–29), and in front of the visceral ganglia, after diverging slightly from its fellow of the opposite side (fig. 62), it crosses dorsal

to the end of the afferent duct. Then it passes ventrally and posteriorly (fig. 61, 62, 66) to open near the midline into the epibranchial cavity, under the visceral ganglion. The efferent duct is lined with columnar, vacuolated and apparently secretory cells, which are not ciliated except at the anterior end and near the external opening.

Venous blood from the posterior end of the body returns by the afferent renal vein (fig. 31, 32, *a r v*) which runs in the mantle, and on a level with the posterior ends of the duct, enters the peri-renal blood spaces (fig. 27–29, 31). After bathing the kidneys, it enters the general venous circulation.

Pelseneer, who, it seems, observed only the posterior ends of the kidney duct, described them as much pouched. In properly prepared specimens of *X. gouldi* I find that, while the body of the kidney is much pouched, the ducts form straight cylindrical tubes. Preserved ship-worms are almost always very greatly contracted and shrunken, and I am inclined to believe that this fact accounts for Pelseneer's results. Also, contrary to the statements in text-books (Lang), I find that the two kidneys of *X. gouldi* do not communicate with each other, as they do in *Pholas* and other forms. In the larva the kidneys lie anterior to the posterior adductor muscle and lateral to the visceral ganglion (fig. 7, 24, 26). As the visceral ganglion passes under and posterior to the muscle, the kidneys accompany it (fig. 9). In the early stages each kidney consists of a simple loop (fig. 9), of which the branch opening to the exterior seems to be excretory. As the ship-worm elongates, the chief secretory portion of the kidney remains with the muscle, while the two ducts become very long and their openings accompany the visceral ganglion.

REPRODUCTIVE ORGANS.

The first stage in which I have observed the reproductive organs is in specimens 2 mm. long, in which there is a mass of undifferentiated primordial germ cells under the visceral ganglion. As growth takes place processes grow out from the original organ till, in the adult, the sexual organs occupy a large part of the posterior portion of the visceral mass (fig. 10, 29–31). As the sexual products develop, they are stored in the cavities of the organ, and especially of that part first formed (fig. 63, 64, *ov*), which serves as a duct for the rest of the organ. The real sexual duct is remarkably short. It is formed as an ectodermal invagination which is already present in specimens 2 mm. long, but which does not break through into the sexual organ till sexual maturity.

In the adult ship-worm the sexes are separate. Young specimens (1–4 cm. long) of *X. gouldi*, however, are very frequently hermaphrodite. As in all such cases the sperms are developed first, it appears that the species may be protandrous. In the adults I have observed no external differences between the sexes. In the male there is, however, a remarkable development of mucous gland cells on the dorsal side of the epibranchial cavity, while in the female they are not usually developed in this region.

SUMMARY.

The results of my work on ship-worms may be summarized as follows:

(1) The larva is a typical free-swimming marine lamellibranch larva.

(2) The whole velum is suddenly cast off and eaten, soon after the attachment of the larva. After the loss of the velum the young ship-worm is, in its general organization, essentially a typical small bivalve.

(3) The loss of the velum in ship-worms and in *Ostrea* (which I have also observed) indicates that the formation of the palps in lamellibranchs has no connection with the velum.

(4) A byssus apparatus is present in the newly attached larva, but is functional for only a few hours.

(5) The position and relations of the sheath of the crystalline style in the larva indicate that this structure, in the more highly specialized lamellibranchs, is homologous with the posterior half of the stomach of forms like *Yoldia* and *Nucula*.

(6) The pleural ganglion of the larva is separate from the cerebral.

(7) The transformation of the larva into the small ship-worm is so rapid as to amount to a metamorphosis. Almost the whole organization is involved—shell, mantle, foot, alimentary canal.

(8) The posterior adductor muscle is the effective agent in forming the burrow, and the shell is the tool with which it works.

(9) In the ship-worms there is a peculiar gland of unknown function in the mantle of the posterior part of the body.

(10) A system of highly specialized muscles manipulate the pallets and are peculiar to ship-worms.

(11) There is on either side but a half ctenidium. The anterior eleven gill filaments form small "plications" on the side of the "head," separated by a wide space from the rest of the gill.

(12) In close association with the gills is a prominent glandular structure of unknown function, which I have called the "gland of Deshayes." It consists of two types of elements of remarkable character.

(13) Through the elongation of the visceral mass, the positions of the two aortæ have been reversed; i. e., the apparent posterior aorta is the real anterior and the apparent anterior the real posterior.

(14) The cæcum of the stomach is very large and apparently an important absorbent organ. The blind end of the style sheath is tubular and of very different character from the outer part. In *Xylotrya* the typhlosole of the anterior part of the intestine is remarkably developed into a complicated in-rolled duplicature.

(15) The nervous system of the adult contains the three pairs of ganglia, well developed, as in typical lamellibranchs. The pedal ganglia are fused together; the cerebral are separated from each other by a long commissure. The "anterior ganglion" is a small ganglion separated from the visceral ganglion, and nerves from it innervate the kidneys, the genital organs, and the osphradium in part.

(16) On the genital duct is an organ of special sense of unknown function. The sensory cells of the osphradium lie beneath the surface epithelium. Their peripheral

ends penetrate the epithelial layer, and break up into brush-like terminations on its surface.

(17) The kidneys lie dorsal to the pericardial cavity. The main secretory part of each kidney is much pouched and lies on the posterior adductor muscle. It is connected with the posterior ends of the pericardial cavity by a very long, narrow duct, and with the exterior by a very long, larger duct which opens under the visceral ganglion.

(18) In the adult ship-worm the sexes are separate. Young individuals (1–4 cm. long) of *X. gouldi*, however, are very frequently hermaphrodite. In all such cases the male cells are developed first, indicating that the species may be protandrous. The sexual duct is very short and is formed as an ectodermal invagination.

LITERATURE.

Barrois, Th. Le stylet crystallin des Lamellibranches. Revue biologique du Nord de la France, t. ii, 1889, p. 209–229, 299–311, and 351–356, pl. iii–v.

Beuk, Stanislaus. Zur Kenntniss des Baues der Niere und der Morphologie von Teredo L. Arbeiten aus dem zoologischen Institut der Universität Wien, bd. xi, 1895–99, p. 260–288, 3 pl. (Deals especially with the structure of the nephridia and briefly with the general organization.)

Deshayes, G. B. Histoire naturelle des Mollusques. Exploration de l'Algérie. 1848.

Egger, Ernst. Jouannetia cumingi Sow. Eine morphologische Untersuchung. Arbeiten aus dem zoologisch-zootomischen Institut Würzburg, bd. viii, 1887, p. 129–199, pl. viii–xi.

Erlanger, R. von. Zur Entwickelung von Paludina vivipara. Morphologisches Jahrbuch, bd. xvii, 1891, p. 337–379 and 636–680, 6 taf.

Grobben, Carl. Die Pericardialdrüse der Lamellibranchiaten. Ein Beitrag zur Kenntniss der Anatomie dieser Molluskenklassen. Arbeiten aus dem zoologischen Institut der Universität Wien, bd. vii, 1888, p. 355–444, taf. i–vi.

Hatschek, B. Ueber Entwickelunsgeschichte von Teredo. Arbeiten aus dem zoologischen Institut der Universität Wien, bd. iii, 1880, p. 1–44.

Korschelt und Heider. Lehrbuch der vergleichenden Entwickelungsgeschichte der wirbellosen Thiere. Jena, 1890.

Lacaze-Duthiers, H. de. Morphologie des Acéphales. I. Anatomie de l'Arrosoir [Aspergillum dichotomum]. Archives de Zoologie expérimentale et générale, sér. 2, t. i, 1883, p. 665–732, pl. xxv–xxix.

Lang, Arnold. Lehrbuch der vergleichenden Anatomie. English translation, 1896.

Lankester, E. Ray. Article Mollusca, Encyclopedia Britannica, 9th ed.

Menegaux, A. Sur les homologies de différents organes du Taret. Comptes-rendus Académie des Sciences, Paris, t. 108, 1889, p. 537–538.

Peck, R. Holman. The minute structure of the gills of lamellibranchiate Mollusca. Quarterly Journal of Microscopical Science, ser. 2, vol. xvii, 1877, p. 43–66, pl. iv–vii.

Pelseneer, Paul. Report of the anatomy of the deep-sea Mollusca collected by H. M. S. Challenger in 1873–76. Challenger Reports, vol. xxvii, 1888, pt. lxxiv, 42 p., 4 pl.

——— ———. Contribution à l'étude des Lamellibranches. Archives de Biologie, t. xi, 1891, p. 147–312, 18 pl.

Quatrefages, A. de. Mémoire sur le genre Taret. Annales des Sciences naturelles, Zoologie, sér. 3, t. xi, 1849, p. 19–73, pl. 1–2, and p. 202–228, pl. 9.

Rice, Edw. L. Die systematische Verwerthbarkeit der Kiemen bei den Lamellibranchiaten. Jenaische Zeitschrift für Naturwissenschaft, bd. xxxi, 1897, p. 29–89, pl. iii–iv.

Snow, C. H. Marine Wood-Borers. Transactions American Society of Civil Engineers, vol. 40, p. 178–209, 9 pl. (Treats, from the engineers' standpoint, of the natural history and depredations of the ship-worms along with other marine forms which are injurious to wooden structures.)

Wilson, E. B. The origin of the mesoblast-bands in annelids. Journal of Morphology, vol. iv, 1890, p. 205–219.

Ziegler, H. E. Die Entwickelung von Cyclas cornea Lam. (Sphærium corneum L.). Zeitschrift für wissenschaftliche Zoologie, bd. xli, 1885, p. 525–569, pl. xxvii and xxviii.

EXPLANATION OF PLATES.

KEY TO LETTERING.

an	Anus.
a a	Anterior adductor muscle.
a c	Anal canal.
a g	Anterior ganglion.
ao a	Anterior aorta.
ao p	Posterior aorta.
a p	Posterior adductor muscle.
a pa	Adductor muscle of palette.
a r v	Afferent renal vein.
au	Auricle.
b a	Afferent branchial vein
b e	Efferent branchial vein.
b n	Branchial nerve.
b s	Blood space of gill lamina.
by	Byssus.
b g	Branchial groove.
c	Cerebral ganglion.
c c	Cerebral commissure.
c s	Crystalline style.
cæ	Cæcum of stomach.
cæ'	Secondary cæcum of stomach.
c h	Cephalic hood of mantle.
col	Collar
c p	Cerebro-pedal connective.
c v	Cerebro-visceral connective.
d D	Duct of the gland of Deshayes.
d a	Dorsal artery.
d k	Dorsal pivotal knob of the shell.
e p c	Epibranchial cavity.
e p ca	Epibranchial canal.
e s	Exhalent or anal siphon.
f	Foot.
f c	Frontal cells of gill.
g	Ctenidium or gill.
g'	Anterior gill filaments.
g a	Ascending limb of gill filament.
g d	Descending limb of gill filament.
g du	Genital duct.
g D	Gland of Deshayes.
gl e p	Gland cells of epidermis.
g o	Genital organ.
i	Intestine.
i f j	Inter-filamentar junction of gill.
i l s	Inter-laminar spaces of gill.
i s	Inhalent or respiratory siphon.
k	Kidney.
k a	Afferent tube of kidney.
k e	Efferent tube of kidney.
l	Liver.
l c	Lateral cells of gill.
l d	Liver duct.
lf c	Latero-frontal cells of gill.
lig	Shell ligament.
m	Mantle.
m c	Mantle cavity.
m g	Mantle groove.
m u	Muscle fibers.
o	Mouth.
œ	Œsophagus.
o n	Osphradial nerve.
o s	Osphradium.
o t	Otolithic vesicle.
ov	Ovary.
p	Pedal ganglion.
pa	Pallet.
p c	Pericardial cavity.
p gl	Gland cells of foot.
p l	Pleural ganglion.
p n	Pallial nerve.
p p	Protractor muscle of pallet.
r	Rectum.
r f	Retractor muscle of pallet.
r g	Respiratory ganglion.
r p	Retractor muscle of pallet.
s	Stomach.
sh	Shell.
s r	Supporting rod of gill filament.
s s	Sheath of crystalline style.
v	Visceral ganglion.
v l	Valve of anterior end of ventricle.
v c	Velar cavity.
v e	Ventricle.
v k	Ventral pivotal knob of the shell valve.
v m	Visceral mass.

DESCRIPTION OF FIGURES.

PLATE VII.

FIG. 1. Newly attached larva of *X. gouldi*. Sketched from life. The foot is shown fully extended. × 110.

FIG. 2. Young shipworm of about 3 days' attachment, from the ventral side. The shell is represented as transparent, with its outline shown faintly, to show the underlying gills at the sides of the visceral mass. × 125.

FIG. 3. Specimen of about 1 week in the wood, slightly contracted, ventral view. To show especially the arrangement of the gills and the extent of the visceral mass. × 95.

FIG. 4. Same stage as figure 3, from the left side. The worm-like form is being rapidly assumed. × 95.

PLATE VIII.

FIG. 5. Young adult, from left side. The extension of the mantle over the shell, as the "cephalic hood," shown on the dorsal side of the latter. The mantle also extends forward over the posterior margin of the shell for a short distance. The siphons are represented as fully extended, but the pallets are not quite fully retracted. The mantle extends over the bases of the pallets as a collar. The attachments to the calcareous lining of the burrow of the muscles of the pallets (*pp*) and of the siphons (*rs*) are shown. The drawing was made from a slightly contracted specimen 10 cm. long.

FIG. 6. Same as 5, the mantle removed to its line of attachment dorsally, at the two ends, removed to the midline. Lines with figures indicate the position of the sections from which figures 28–35, inclusive, were drawn.

PLATE IX.

FIG. 7. Larva a few hours after attachment, from the right side. The velar membrane has shrunken and the cells of the velum have been ingested. The shell, mantle, gill and liver lobe of the right side removed. The cells of the disintegrating velum are not represented. The foot not fully extended. × 213.

FIG. 8. About the same stage as figure 2, from the left side. The left shell, mantle, and gill represented as removed. The double origin of the cerebral ganglion is still shown. The visceral ganglion and kidney still lie in front of the posterior adductor. The cæcum largely fills the foot, and has crowded the crystalline style and intestine to the left side. × 167.

PLATE X.

FIG. 9. Same as figure 4, the left shell, mantle, and gill removed. The pericardial space, with the included and associated parts, has taken up a position posterior to the adductor muscle. The secondary cæcum of the stomach has been formed. The gills project posterior to the visceral mass. × 95.

FIG. 10. Adult, anterior half of the body, with the left shell valve, mantle, and gill removed, and the pericardial cavity laid open. Half of the posterior adductor removed.

PLATE XI.

FIG. 11. Right shell valve of newly attached larva, internal view. The rudimentary apophyses are shown below the teeth. × 110.

FIG. 12. Same, left shell valve.

FIG. 13. Shell of newly attached larva, end view. × 110.

FIG. 14. Shell of shipworm that has been in the wood about 1 day, front view. The first row of teeth upon the shell, the apophyses and the pivotal knobs have been formed. The shell gapes at both ends. × 110.

FIG. 15. Left shell valve of specimen about 1 mm. long. Oblique view. The larval shell still shown. × 110.

FIG. 16. Left shell valve of specimen 5 mm. long. × 23.

FIG. 17. Left shell valve of large adult. The lines of growth are shown natural size and relations, but the teeth are omitted. × 10.

FIG. 18. Front view of shell of adult. × 7.

FIG. 19. Internal view of right valve, *apo*, apophysis; *aa* and *ap*, attachment of anterior and posterior adductor muscles. × 7.

FIG. 20. Left pallet of specimen 5 mm. long. × 70.

PLATE XII.

FIG. 21. Dorsal gland of the posterior part of the mantle. Section of whole gland of specimen 5 mm. long. The letters are placed in the epibranchial cavity; *fol* are secretory follicles; *du*, duct. × 700.

FIG. 22. Sagittal section of a newly attached larva. The very large glands of the foot occupy a large part of the mass of the latter. A large quantity of material derived from these glands lies adjacent to the byssus gland. The disintegrating cells of velum, some of which have been eaten, are not represented. × 540.

PLATE XIII.

FIG. 23. Transverse section of larva. From a specimen in which the foot was more protracted than shown in figure 22. The ventral mantle edge is filled with cells gorged with material, evidently for the rapid growth of the shell during its transformation. × 440.

FIG. 24. Horizontal section of newly attached larva in which the cavity of the velum was partially obliterated. On the left side the contents of the gland of Deshayes are shown; on the right side, the duct. × 440.

PLATE XIV.

FIG. 25. Transverse section of a specimen 1 mm. long, to show especially the extent and relations of the gland of Deshayes. × 125.

[NOTE.—Figs. 26–33 are a series of transverse sections of a specimen 10 cm. long, along the lines indicated in figure 6. The drawings were made with the aid of a camera and afterwards touched up, though not essentially changed. The details of structure are semidiagrammatic. The right side in the sections is on the left side of the observer. All × 15.]

FIG. 26. Section through the posterior adductor muscle and cephalic hood. Tubular part of style sheath to the right side. Posterior aorta asymmetrical, on the right side.

FIG. 27. Section through the wound typhosole, the canal-like anterior end of the pericardial cavity and the posterior end of the body of the kidney.

FIG. 28. Section through the large posterior liver mass. Shows the distribution and character of the two different parts of the liver.

FIG. 29. Section through the large ventricle and the ovary.

FIG. 30. Section through the opening of the kidney into the pericardial cavity, the anterior ganglion, and the posterior ends of the auricles. The two arrows from the right indicate the course of the water currents between the gill laminæ, the one pointed dorsally, that of blood through the gill lamina. The number and distribution of the interlaminar connections indicated by dots.

PLATE XV.

FIG. 31. Section near the posterior end of the visceral mass.

FIG. 32. Section to illustrate the structure in the long region between the visceral mass and the muscular collar. In this figure, but not in the other transverse sections, the corpuscles of the blood are represented in the blood vessels.

FIG. 33. Section through the "collar," pallet handles, and base of siphons.

FIG. 34. Section of a pallet handle and its sheath. The attachment of the ventral retractor muscle is shown. × 272.

FIGS. 35, 36. Diagrams of the posterior end of body of adult, left side, to show the arrangement of the siphons and pallets and their muscles. In figure 35 the siphons are represented as extended, the pallets as retracted; in figure 36 the siphons are represented as contracted, the pallets as protracted. *Ca*, calcareous lining of burrow.

PLATE XVI.

FIG. 37. Lamina of gill of young *T. navalis*, to show especially the distribution of the gland of Deshayes, in which the elements are represented semidiagrammatically. The arrows indicate the course of the water over and blood currents through the gill lamina. The epibranchial cavity and the blood vessels are indicated by the letters which are placed in these spaces. × 208.

FIG. 38. Transverse section of three laminæ of *Xylotrya gouldi* almost in the line of the lower arrow in figure 30. Two interlaminar junctions are shown. The two elements of the gland of Deshayes are shown, both as to character and distribution. × 208.

PLATE XVII.

FIG. 39. Tangential section of a gill of *Xylotrya gouldi* to show the distribution of the interlaminar junctions. × 156.

FIG. 40. Transverse section of three gill laminæ, along the line shown in figure 37, near the tip of the lamina, so as to show the interlaminar junctions on one side. × 180.

FIG. 41. Section of the three most anterior gill filaments at the side of the "head." The one to the left is the first one and only a half filament. The letters are placed in the epibranchial canal. × 430.

FIG. 42. Group of cells from the branchial groove at the edge of the gill, showing the character of the ciliated cells and the mucous cells among them. × 950.

FIG. 43. Section of that part of the branchial groove which connects the two parts of the gill. × 430.

FIG. 44. Section of the duct of the gland of Deshayes between the two parts of the gill (i. e., between the main part of the gill and the anterior separated filaments of the head). The epibranchial canal is shown to the left and the afferent branchial vein to the right. The great variety in the cells in the duct is represented. × 695.

PLATE XVIII.

FIG. 45. Section of two tubes of the gland of Deshayes from a gill lamina. In the walls of the gill lamina are shown sections of the dendritic processes which penetrate among all portions of the glandular structures. × 925.

FIGS. 46 and 47. Coarser and finer portions of the dendritic processes from the gill lamina of *T. navalis* represented in figure 37. The distribution and contents of these structures are represented in detail. × 1267.

FIGS. 48–51. Four stages in the development of the structures of the second factor of the gland of Deshayes. × 1267.

PLATE XIX.

FIG. 52. Heart of specimen 2 mm. long, dorsal view. Openings from auricles show through the walls of the ventricle. × 180.

FIG. 53. Heart of young adult. The anterior aorta is represented as turned to one side and the auriculo-ventricular valves as showing through the wall of the ventricle. About × 10.

FIG. 54. Longitudinal section of the ventricle and vessels of a specimen 4 mm. long. The arrows indicate the course of the blood. The posterior adductor muscle and the wall of the stomach represented in part. The anterior end is to the right of the figure. The letters are in pericardial cavity and stomach. × 272.

FIG. 55. Longitudinal section of the anterior part of the ventricle and vessels of a specimen 10 cm. long. × 272.

FIG. 56. Group of cells from the main portion of the style sheath. × 575.

FIG. 57. Same from tubular portion. × 575.

FIG. 58 A. Group of cells from the liver, which show the usual liver structure, and 58 B, from its modified portion. × 575.

PLATE XX.

FIG. 59. Nervous system of newly attached larva, showing the pleural ganglion still separate from the cerebral, and the visceral ganglia still wide apart. The details of the nerves are not shown. × 430.

FIG. 60. Nervous system of adult, dorsal view, except that the pedal ganglion is shown more from behind.

FIGS. 61 and 62. Diagrams to show the relations of the ends of the kidneys, genital duct, pericardial cavity, and visceral ganglion. Figure 61 lateral and figure 62 dorsal view.

PLATE XXI.

FIG. 63. Transverse section of the anterior ganglion and genital duct, to show the connection between the cerebro-visceral connective and anterior ganglion and the origin of the sensory nerve and its distribution to the genital duct. Only a part of the sense organ was included in the section, which is from *T. navalis*, though it might represent *X. gouldi* equally well. × 272.

FIG. 64. Longitudinal section of the genital duct to show its extent and character and the sense organ of the genital duct. The end of the ovary is shown, as also the folded kidney near its pericardial opening. × 272.

FIG. 65. Section of the osphradium, vertical to the surface, to show the structure of the osphradium and the two types of sensory cells, with their brushlike terminations. × 1210.

FIG. 66. Tangential section of the osphradium, to show the distribution of the processes of the sensory cells among the nuclei of the epithelial layer. × 950.

PLATE VII

Fig.1

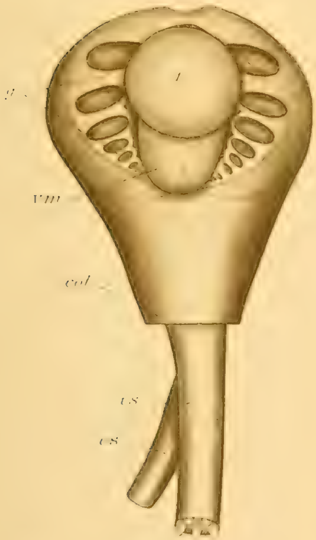


Fig.2

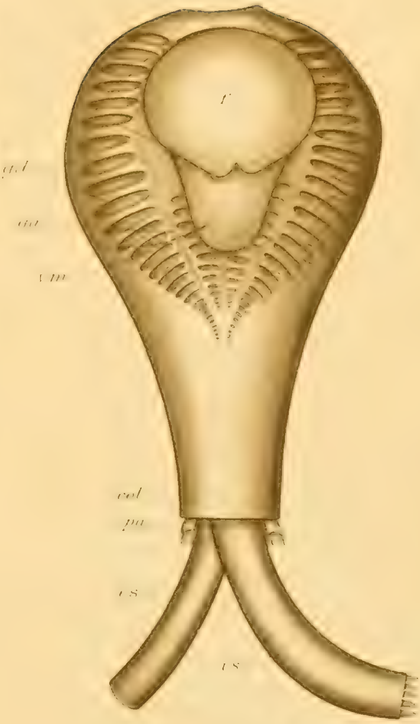


Fig.3

Fig.4

Fig. 5

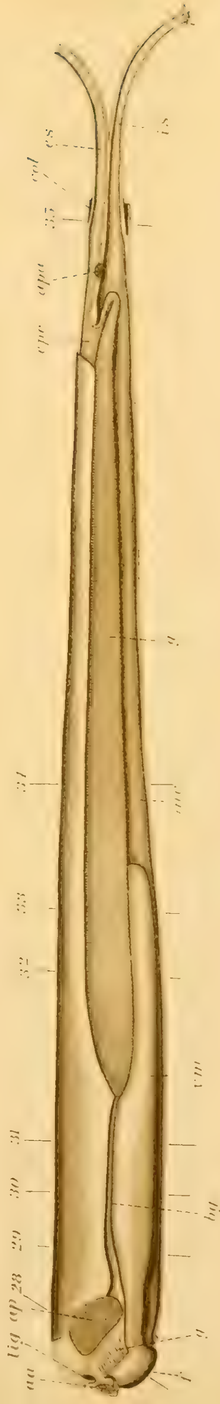


Fig. 6

Fig.7

Fig.8

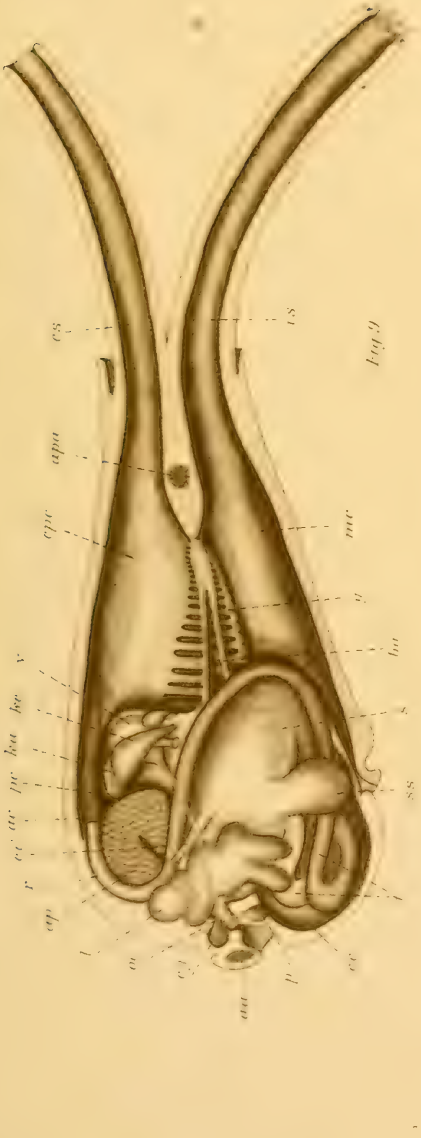


Fig. 9

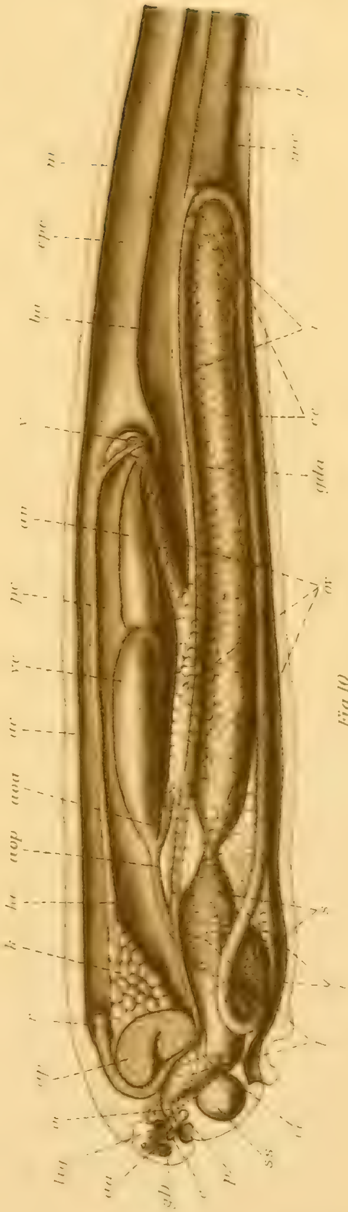


Fig. 10

Fig 11

Fig 12

Fig. 13

Fig 14

Fig 15

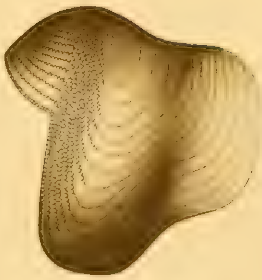


Fig. 16

Fig 17

Fig 18

Fig 19

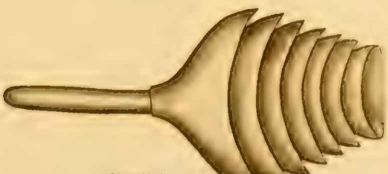


Fig 20

Fig. 21

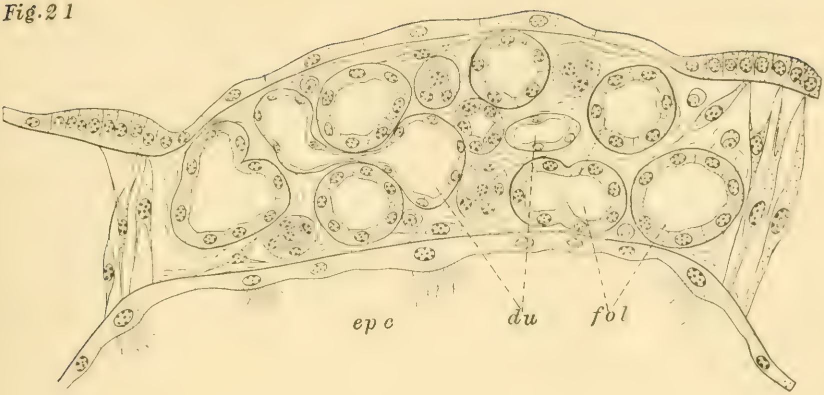


Fig. 22

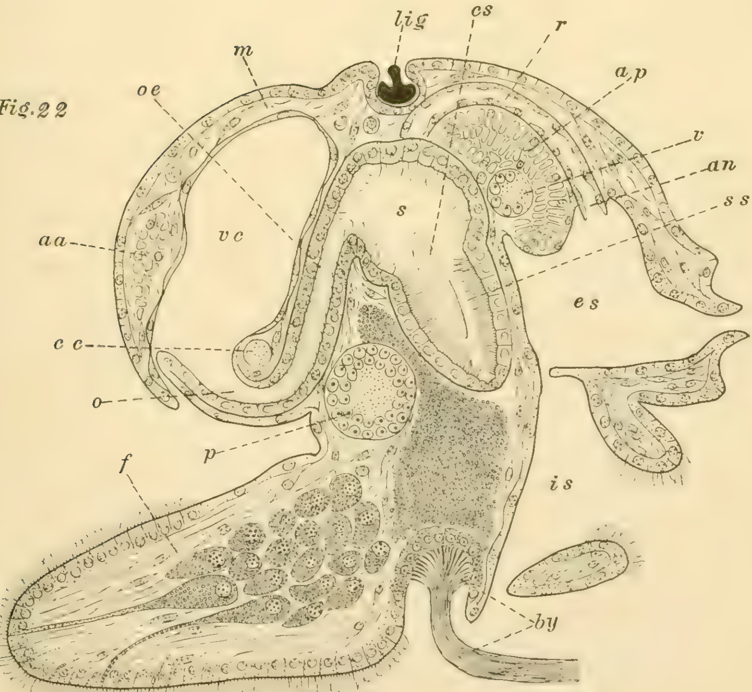


Fig. 23

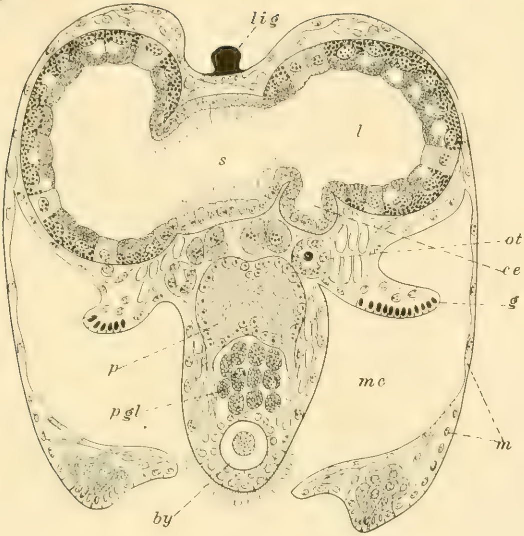
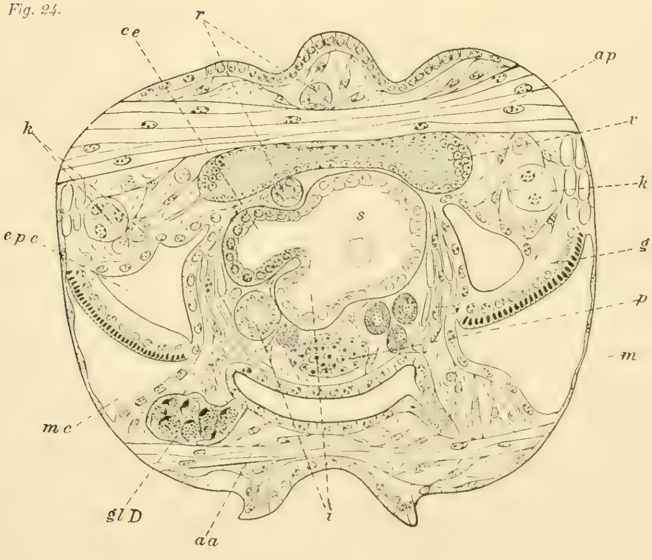


Fig. 24.



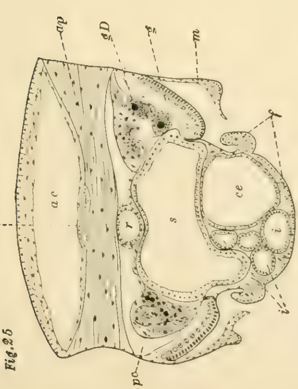


Fig. 25

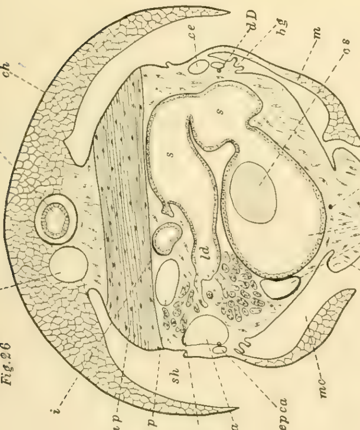
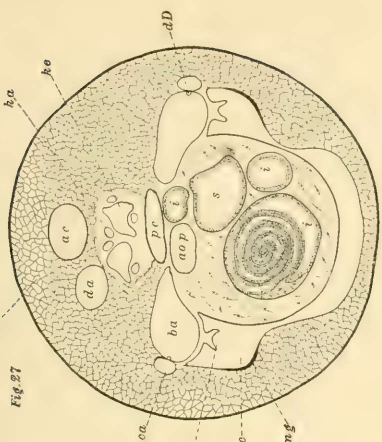


Fig. 26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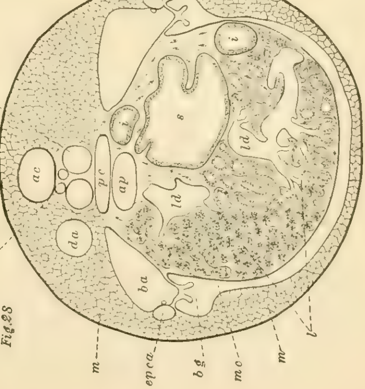
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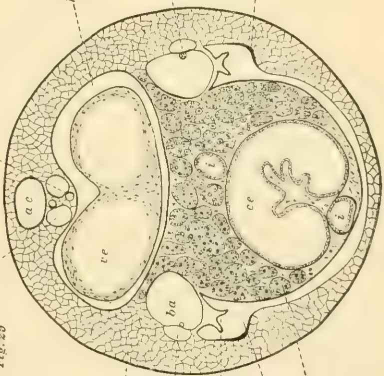
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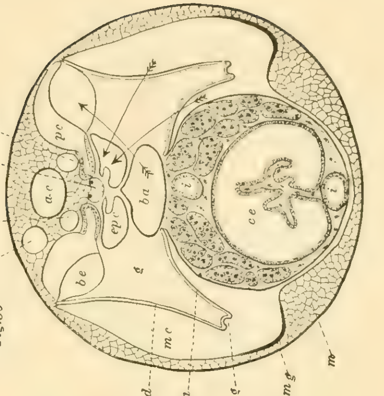


Fig. 30

Fig. 31

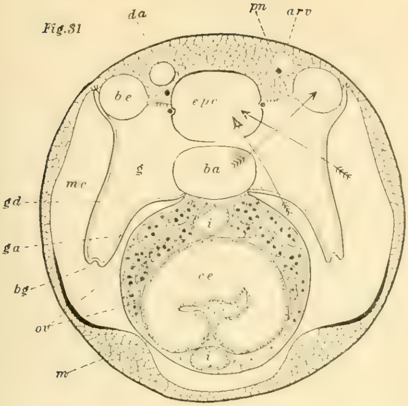
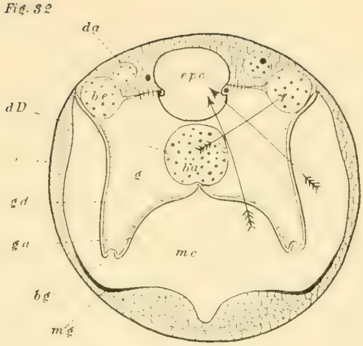


Fig. 32



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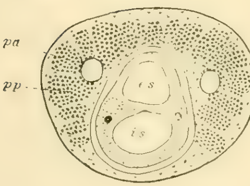

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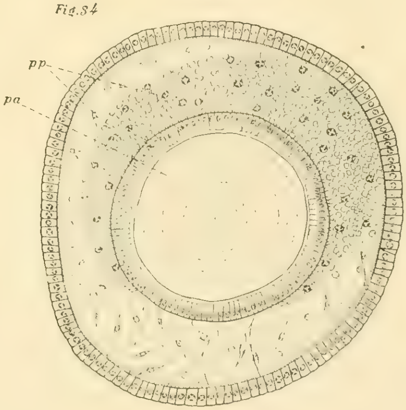

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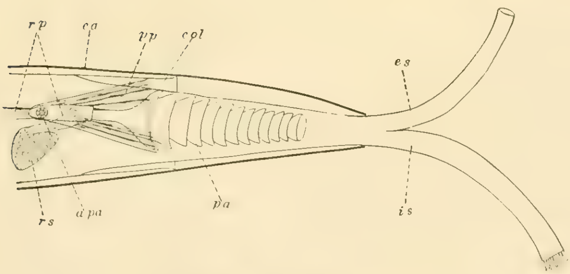

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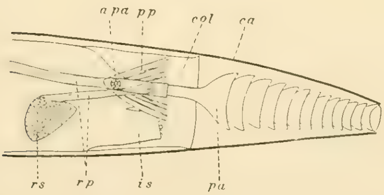

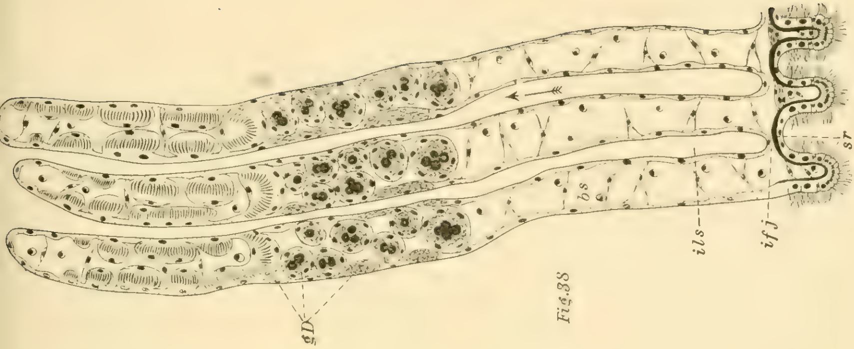

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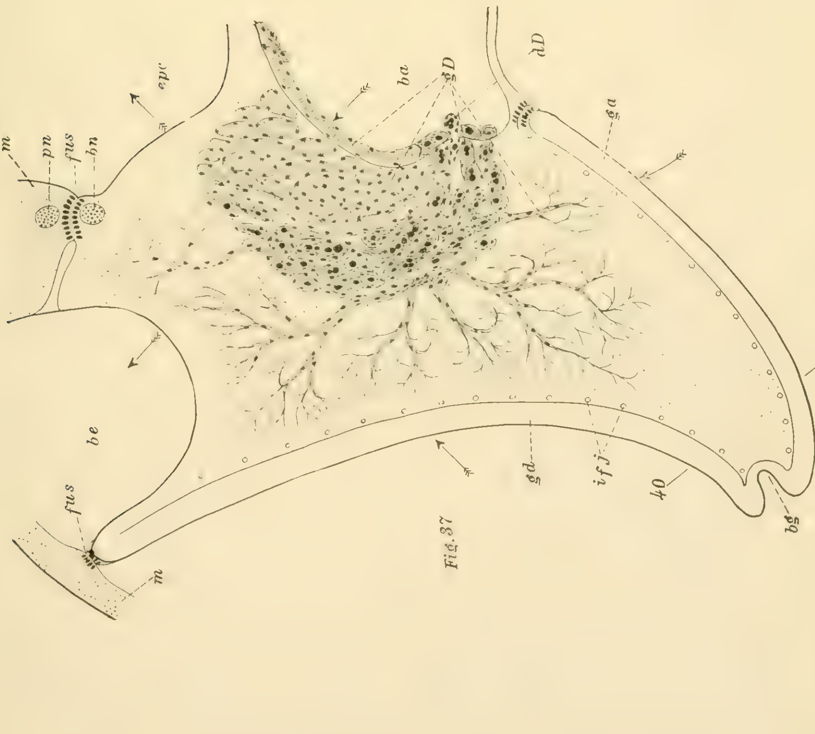
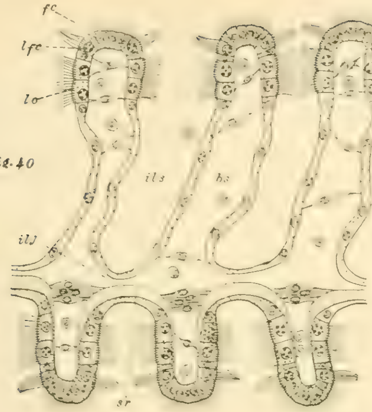


Fig. 37

Fig. 40



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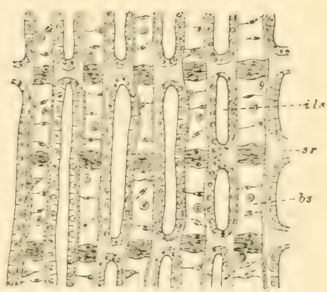

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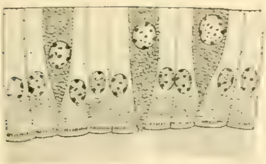

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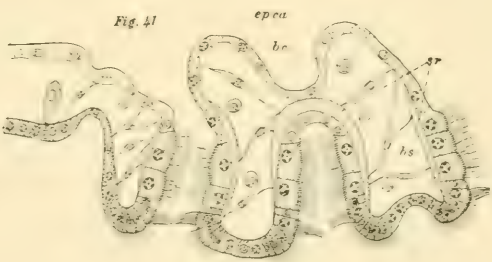

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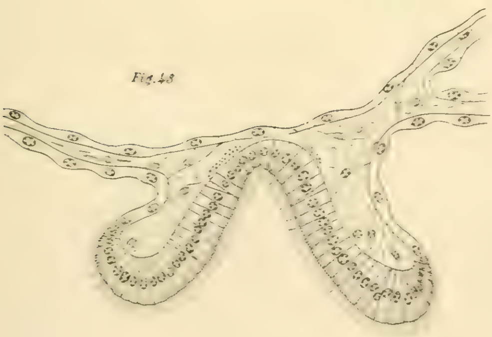

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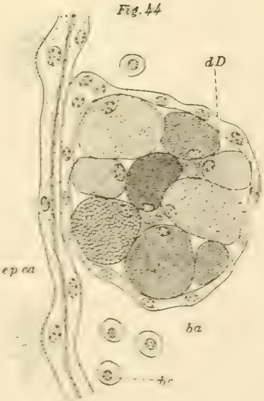


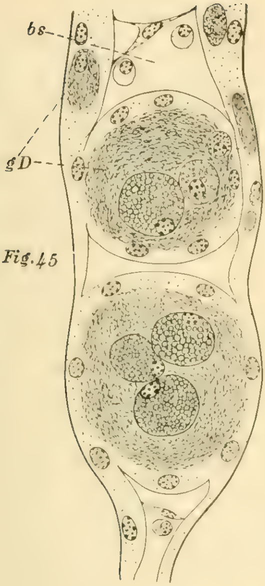
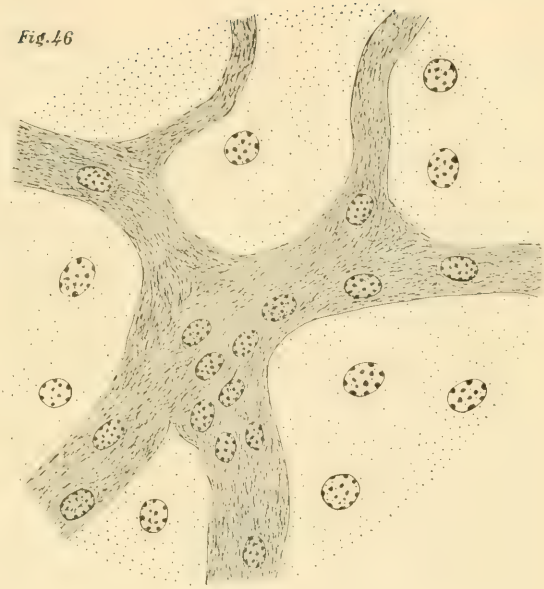


Fig. 45

Fig. 46



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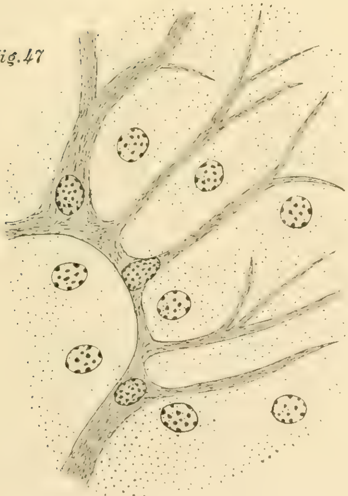


Fig. 50

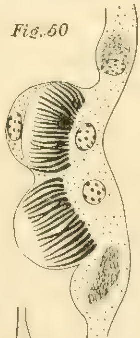


Fig. 51

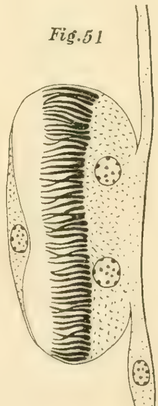


Fig. 49

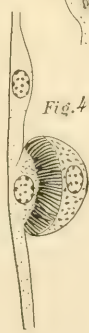


Fig. 48

PLATE XIX.

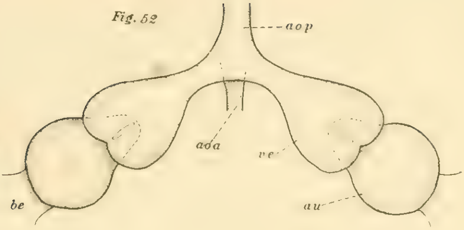
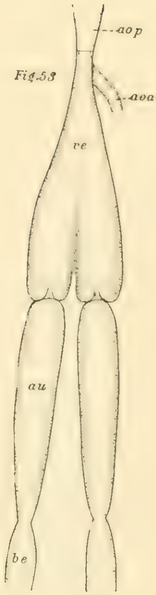


Fig. 52



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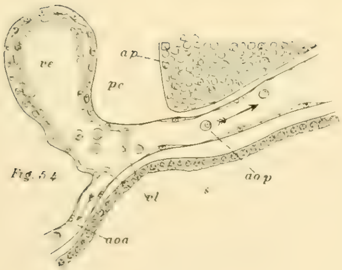


Fig. 54

Fig. 55

Fig. 56

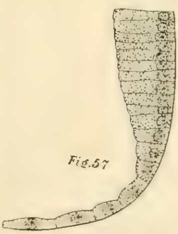


Fig. 57

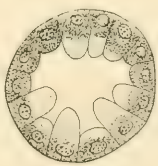


Fig. 58 A

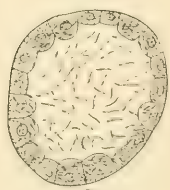
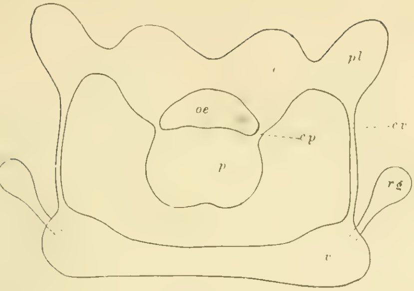


Fig. 58 B



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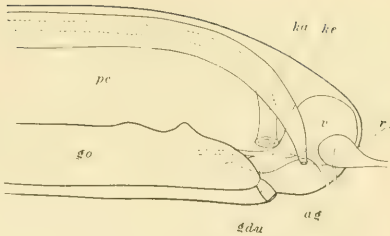


Fig. 61

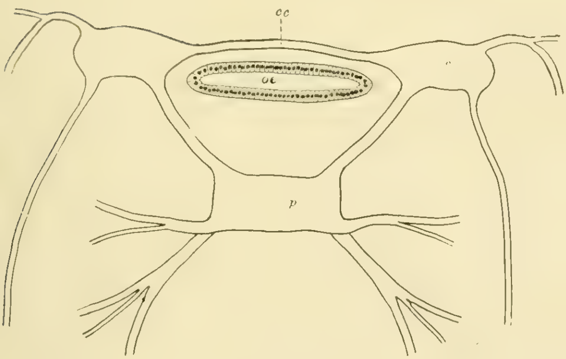
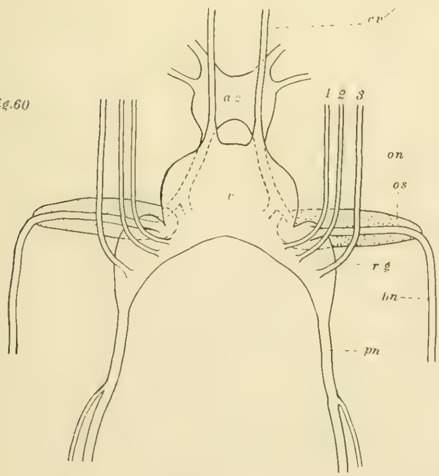


Fig. 62

Fig. 60



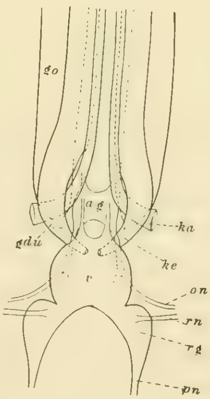
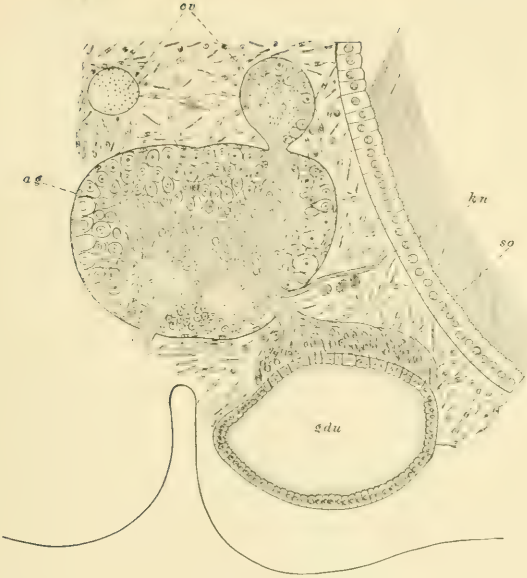


Fig. 63



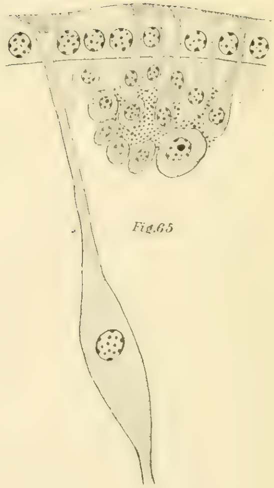


Fig. 65

Fig. 66

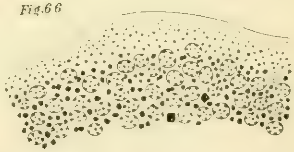


Fig. 64

FISHES FROM ISLANDS OF THE PHILIPPINE ARCHIPELAGO

By David Starr Jordan and Robert Earl Richardson

BUREAU OF FISHERIES DOCUMENT NO. 640

FISHES FROM ISLANDS OF THE PHILIPPINE ARCHIPELAGO.

By DAVID STARR JORDAN and ROBERT EARL RICHARDSON.

In 1906 Mr. Richard Crittenden McGregor, a naturalist employed by the government of the Philippine Islands, brought to Stanford University a large collection of fishes made by him in outlying islands of the Philippine group. He was unable to work up this collection himself, as he had intended to do, and it was presented by him to the Museum of Stanford University. In the present paper is given an account of the species thus obtained. A series of these specimens has been presented through the Bureau of Fisheries to the United States National Museum. The localities represented in the collection are the islands of Calayan, Ticao, Lubang, Mindoro, Sibuyan, Romblon, and Cuyo; Aparri, Cagayancillo, and Manila, on the island of Luzon, and Iloilo, on the island of Mindanao.

The following species are thought to be new to science. The numbers in parentheses apply to the type specimens in Stanford University Museum.

Pisoodonophis macgregori (20210).
Leiuranus lithinus (20211).
Cœcula mindora (20209).
Muræniehthys thompsoni (20201).
Barbodes hemictenus (20213).
Atherina panatela (20203).
Doryrhamphus macgregori (20202).
Hippocampus barbouri (20205).
Gnathypops dendritica (20313).
Abudefduf sapphirus (20207).
Aparrius (new genus) (acutipinnis).
Antennarius lithinostomus (20204).

The notes on life colors and the vernacular names are given on the authority of Mr. McGregor.

Family CARCHARIIDÆ.

SCOLIODON Müller & Henle.

1. **Scoliodon walbeehmii** (Bleeker).
Three specimens from Manila, 8 inches long.

Family DASYATIDÆ.

HIMANTURA Duméril.

2. **Himantura uarnak** (Forskål). *Pagi.*
One specimen from Manila, 10 inches long to base of tail; length of tail, 25 inches; spots blackish, on olive ground.

Family ELOPIDÆ.

ELOPS Linnæus.

3. **Elops saurus** Linnæus. *Bilbit.*
One specimen from Manila, 7.50 inches.

Family CHIROCENTRIDÆ.

CHIROCENTRUS Cuvier.

4. **Chirocentrus dorab** (Forskål).

One specimen from Manila, 14.50 inches; depth, 6.75 inches.

Family CHANIDÆ.

CHANOS Lacépède.

5. **Chanos chanos** (Forskål). *Bangos.*

One specimen from Manila, 8.75 inches.

Family CLUPEIDÆ.

DUSSUMIERIA Cuvier & Valenciennes.

6. **Dussumieria elopsoides** (Bleeker).

One specimen, 2.60 inches long, from Iloilo. Depth 5.20; head 3.50; eye 3.20; maxillary equal to eye.

7. **Dussumieria hasseltii** Bleeker.

Depth 5.20 to 5.90; head 3.50; eye 3.75; maxillary 1.25 to 1.40 times diameter of eye. This species differs distinctly from *Dussumieria elopsoides* in its longer maxillary and its smaller scales. Eleven specimens from Manila, 2.75 inches long.

HARENGULA Cuvier & Valenciennes.

8. **Harengula sundaica** (Bleeker). *Sardina.*

Depth 3.16 to 3.33. Color silvery; upper third dark blue; dorsal and caudal dusky; other fins clear. In alcoholic specimens there are traces of a row of black spots along upper part of side, though much fainter than in *Harengula gibbosa.*

Specimens as follows: Manila, six, 3.50 to 4.50 inches; Iloilo, one, 2.60 inches; Aparri, one, 4.25 inches.

9. **Harengula gibbosa** (Bleeker). *Sardina.*

Depth 3.83. Life colors as in *Harengula sundaica.* This is a slightly slimmer fish than *Harengula sundaica,* and shows much more plainly the row of dark spots on the upper portion of the side.

Two specimens from Manila, 3.30 and 4.50 inches long.

10. **Harengula moluccensis** (Bleeker).

Depth 4.25; head 4.20. Spots on upper portion of sides faint.

Two specimens from Manila, 3.50 inches.

ILISHA Gray.

11. **Ilisha hœvenii** (Bleeker). *Sardina.*

One specimen from Manila, 3.20 inches.

Family DOROSOMATIDÆ.

ANODONTOSTOMA Bleeker.

12. **Anodontostoma chacunda** (Hamilton-Buchanan). *Cabase.*

One specimen from Manila, 5.25 inches, and one from Iloilo, 3.85 inches long.

Family ENGRAULIDÆ.

ANCHOVIA Jordan & Evermann.

(*Stolephorus* Bleeker, not of Lacépède.)

13. **Anchovia hamiltonii** (Gray). *Dumpilas.*

Depth 3.50; head 4.50; dorsal 12; anal 38; backward process of maxillary extending beyond opercular opening and nearly to base of pectoral fin.

One specimen, 6 inches long, from Manila, and one, 3.60 inches long, from Iloilo.

14. **Anchovia bœlama** (Forskål).

Depth 4.33; head 3.75; dorsal 13; anal 30; scales 31–44. Life color metallic silvery, specked with brown above; a small blood-colored spot behind upper margin of opercle; caudal washed with pale yellow and red; occiput with a touch of red; muzzle red, with many small black dots. The maxillary process is short, not extending beyond gill-opening.

Seven specimens from Cagayancillo and one from Iloilo, 2.50 to 3.50 inches long. This species occurs near the shore in schools. Great numbers are taken at Cagayancillo with circular casting nets. (McGregor.)

15. Anchovia setirostris (Broussonet).

Depth 4.30; head 4.30; eye 3.60; dorsal II, 12; anal I, 31; scales 35. Maxillary with an extremely long backwardly directed process, reaching almost to the vent.

One specimen from Aparri, 3.50 inches long.

Family SYNODONTIDÆ.

SYNODUS Bloch & Schneider.

16. Synodus japonicus (Houttuyn). (*Synodus varius* (Lacépède).)

General color gray, mottled and finely speckled with dark brown; white below. One specimen 3.75 inches long and one 6 inches, from Cuyo.

SAURIDA Cuvier.

17. Saurida argyrophanes Richardson.

Depth 7; head 4.50; eye 5.30; dorsal I, 11; anal I, 10; scales 57; pectoral 1.6 in head. Color in life brown above with a silvery spot on each scale; sides silvery; belly dead white with but little sheen; ventral and anal white; other fins dusky.

Four specimens from Manila, 3 to 9 inches long.

18. Saurida gracilis (Quoy & Gaimard).

One specimen, 3 inches long, from Cuyo.

Family ANGUILLIDÆ.

ANGUILLA Thunberg.

19. Anguilla mauritiana Bennett. *Kiwit.*

Color in life olive green, mottled with dark brown; belly white.

One specimen from a brackish estuary at Calayan, 16 inches long, and one from Mindoro Island, 15 inches long. Mr. McGregor records a specimen 31 inches long, whose stomach contained a snake nearly as long as the fish.

Family MURÆNESOCIDÆ.

MURÆNESOX McClelland.

20. Muræenesox cinereus (Forskål). *Pindanga.*

Two specimens from Manila, 10 inches long.

Family MYRIDÆ.

MURÆNICHTHYS Bleeker.

21. Murænichthys thompsoni Jordan & Richardson, new species.

Head 6.60; depth equal to distance from tip of snout to back of orbit; length of head and trunk equal to .80 of tail; snout 1.33 times eye; cleft of mouth 2.75 in head, the maxillary extending a distance

FIG. 1.—Murænichthys thompsoni, new species. Type.

behind orbit equal to length of snout; eye 18 in head; dorsal origin almost exactly midway between vent and gill-opening, the fin very low anteriorly; tail tapered to a sharp point, tipped with a short

caudal fin continuous with dorsal and anal; no pectorals; gill-openings a distance behind eye equal to 2.25 times length of maxillary; vomerine teeth in two rows; teeth in jaws uniserial. Color in spirits light brownish, everywhere specked finely with darker, except on belly, which is pale.

This species is known to us from a single specimen, 3.75 inches long, collected in Manila Bay by Dr. J. C. Thompson, of the United States Navy, for whom the species is named. The type is no. 20201, Stanford University.

In its large mouth and in many other features this eel resembles *Muræenichthys macrostomus* Bleeker, but the insertion of the dorsal fin is different.

Family OPHICHTHYIDÆ.

PISOODONOPHIS Kaup.

22. Pisoodonophis cancrivorus Richardson. *Igot.*

Depth 32; head 8.5; cleft of mouth 2.8 in head; eye 1.75 in snout; pectoral 3.75; head in distance from gill-opening to vent 2.5; trunk equal to head and body equaling .78 of tail, in which it is contained 1.37 times; dorsal inserted over middle of pectoral. Color in life light brown above; white below; chin and throat pale yellow; pectoral yellowish; dorsal edged with black; anal edged with black on posterior border.

One specimen from Cuyo, 20 inches long, and one from Manila, 28 inches.

Fig. 2.—Pisoodonophis macgregori, new species. Type.

23. Pisoodonophis macgregori Jordan & Richardson, new species.

Depth 33; head 7.90 in total length; head in distance from gill-opening to vent 2; combined length of head and trunk equal to .66 of tail; cleft of mouth 2.75 in head; eye 1.50 in snout; pectoral 3.50; dorsal inserted over first fifth of pectoral; teeth molar in irregular double bands on jaws and vomer.

Color brown above and on sides, finely punctulated; under parts paler; dorsal and anal rather broadly margined with blackish.

This species has the body shorter and the dorsal inserted farther forward than in *Pisoodonophis cancrivorus.*

One specimen, 10 inches long, from Manila; no. 20210, Stanford University.

OPHICHTHUS Ahl.

24. Ophichthus tapeinopterus (Bleeker).

One specimen from Manila, 10.75 inches long.

25. Ophichthus grandoculis (Cantor).

Depth 28; head 9.8 in total length; head in distance from gill-opening to vent 2.9; combined length of head and trunk equal to .66 of tail; cleft of mouth 3.75 in head; pectoral 3.20; dorsal inserted over middle of reflexed pectoral; teeth in jaws uniserial; teeth on vomer in a double row anteriorly.

Body very finely and uniformly punctulated with brownish above and below and on sides, except for lateral part of abdomen, which is whitish; dorsal and anal edged with black.

One specimen, 10 inches long, from Manila.

LEIURANUS Bleeker.

26. Leiuranus lithinus Jordan & Richardson, new species.

Depth 32; head 10.5 in total length; tail equal to trunk and head; length of head 5 in distance from gill-opening to vent; head and trunk equal to tail; cleft of mouth 3.50 in head; pectoral 4.15; dorsal

inserted over middle of reflexed pectoral; nose rather rounded, scarcely twice eye; teeth in jaws uniserial, those in the upper jaw not so sharp as those in the lower; no teeth on vomer behind front of maxillaries.

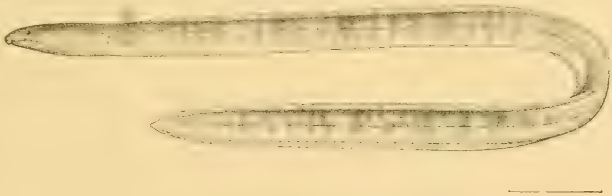


FIG. 3.—Leiuranus lithinus, new species. Type.

Color brownish, mottled with darker above and on sides, the dark color in places tending to form vague crossbands, which do not extend on belly. (*λίθινος*,, marbled, like stone.)

Here described from a single specimen, 12 inches long, from Cuyo; no. 20211, Stanford University.

CŒCULA Vahl.

27. Cœcula mindora (=*Dalophis* Rafinesque) Jordan & Richardson, new species.

Head 2.60 in distance from gill-opening to vent; depth 25 in total length; eye 25 in head; snout 7; cleft of mouth very wide, extending far behind eye, 2.50 in head; teeth in jaws fine, uniserial; a lengthwise row of about 6 large sharp teeth in a single row on the vomer, behind the junction of the maxillaries; tip of upper jaw with 3 large teeth in a transverse series, behind them a wide shallow cross notch into which the tip of the mandible closes; dorsal inserted one-quarter of the head's length behind the gill-openings; pectorals wholly wanting.

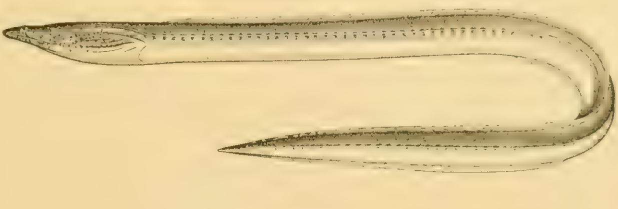


FIG. 4.—Cœcula mindora, new species. Type.

Color above lateral line a uniform finely punctulated dark brown; scattered punctulations extending a short distance below lateral line on trunk, a nearly sharp line separating upper from lower color on the tail; lateral line with a series of small more or less stellate whitish spots, about size of eye; belly pale; top and tip of snout blue-black; under jaw specked and splashed with bluish black.

One specimen, 15 inches long, from Mindoro Island; no. 20209, Stanford University.

Family MURÆNIDÆ.

GYMNOTHORAX Bloch.

28. Gymnothorax pictus (Ahl).

Life colors dark olive green, with mottlings of whitish olive in fine pattern; larger light areas on sides; no black at angle of mouth and none at gill-opening.

One specimen, 8 inches long, from Cagayancillo, and one, 4.50 inches long, from Ticao Island.

29. Gymnothorax litus (Richardson).

In life finely mottled with gray and brown; almost pure gray below. This species has no black at corners of mouth or on gill-openings.

One specimen from Cuyo, 9.75 inches long, and one from Cagayancillo, 10 inches.

30. Gymnothorax flavomarginatus (Rüppell).

A young specimen, 8 inches long, from Calayan. In this specimen, as in young individuals of the same size from Apia, Samoa, the ground color is very dark, the small spots being scarcely distinguishable in the nearly uniform blackish of the ground. There is a dark streak at the angle of the mouth and the gill-opening is in the middle of a black spot; tip of caudal white.

31. Gymnothorax richardsonii (Bleeker).

Gymnothorax richardsoni, Bleeker, Atlas, Muræn., 100, pl. XLII, fig. 2, 1864.
Gymnothorax scoliodon, Bleeker, op. cit., 101, pl. XL, fig. 2.
Gymnothorax ceramensis, Bleeker, Ned. Tijds. Dierk., I, 1863, 261; Atlas, Muræn., 101, pl. XXXIII, fig. 3, 1864.
? *Muræenophis lineatus* Lesson, Voy. Coquille, 127, pl. II, fig. 1, 1830; Oualan (figure very poor).
Muræna richardsonii Bleeker, Nat. Tijds., III, 1852, 296; Wahai, Ceram, Padang, Sumatra.

Body slender, compressed, the depth at vent and at middle of tail about same, 18 in total length; tail a little longer than body; dorsal beginning a little in advance of gill-opening, not conspicuously higher on tail than on trunk, its greatest height considerably less than half the depth of the tail directly beneath; tail long, slender, and tapering, the dorsal and anal bordering it symmetrically and meeting in the middle line behind in an acute tip.

Body and fins crossed by many narrow vertical broken streaks or bands of dark color, more or less broken into vermiculations, especially forward; corner of mouth with a dark streak, above and below (in front) which is a larger light spot; chin pale.

One specimen, 8 inches long, from Sibuyan.

This species seems to be different from Lesson's *flaveolus*,[a] and perhaps also from his *lineatus*,[b] both of which species are said by Lesson to have an especially elevated dorsal fin. Specimens from Apia, Samoa, referred by Jordan & Seale to *Gymnothorax lineatus*, have the height of the dorsal more than half the depth of the tail underneath, and the body is less slender and the tail stouter and much less tapered than in *Gymnothorax richardsonii*, as shown in Bleeker's figure of both this and *ceramensis*. In the Apia specimens the caudal border, also, is broadly and asymmetrically rounded, not pointed, being most developed ventrally. Lesson's figures, though evidently very poor in details, show two eels of quite different relative length. It seems that the Apia specimens are more likely to be *flaveolus* than *lineatus*, the latter being represented as the slenderer fish in the figure. It seems quite possible that *lineatus* may not be different from Bleeker's *richardsonii*. *Gymnothorax detactus* Bryan & Herre appears likewise to be scarcely, if at all, different from the present species.

32. Gymnothorax petelli (Bleeker).

Muræna petelli Bleeker, Nat. Tijds., XI, 1855, 84; Java. Günther, Cat., VIII, 1870, 105; Java, Mauritius.
Gymnothorax petelli Bleeker, Atlas, Muraen., 99, tab. XXXII, fig. 1, 1864. Jordan & Seale, Bul. U. S. Fish Comm., XXV, 1905, Samoa.
(?) *Muræna interrupta* Kaup, Apodes, 67, fig. 51, 1854; Red Sea.
Gymnothorax leucacme Jenkins, Bul. U. S. Fish Comm., XXII, 1902, 427, fig. 7; Honolulu.
Gymnothorax waialuæ Snyder, Bul. U. S. Fish Comm., XXII, 1902, 520, pl. 6; Waialua (near Honolulu).

A very young specimen of this species, 3 inches long, from Calayan, agrees perfectly with the figure and description of *Gymnothorax waialuæ* Snyder. The black crossbands are 17 or 18 in number, are complete below, and mostly wider than the adjacent pale interspaces. There is a black half band across the occiput, which reaches forward in a broad point between the eyes. The side of each upper jaw is black as far back as the eye. The tip of the nose is white, and from it a white band extends backward over the muzzle to the forehead, where it sends a branch outward and downward to each eye, forming a Y on forehead and muzzle. Adults of *Gymnothorax petelli* from Apia, Samoa, show the essentials of this color pattern, including the white Y on nose. The black crossbands on the body seem to become relatively wider (than the interspaces) with age.

"*Gymnothorax rüpelliæ*" McClelland (=*reticularis*, Bleeker, not of Bloch) has the black cross bands much narrower than the interspaces, both in adults and young, and has no black on the nose. It is evidently distinct from *Gymnothorax petelli*, as thought by Doctor Günther, who had both adult and young specimens, from Borneo and the Moluccas. *Gymnothorax reticularis* Bloch (not of Bleeker) has the cross bands broader than the interspaces and the nose without band, but the head and back are spotted and vermiculated (as is shown in the figures by Bloch, Temminck & Schlegel, and Kaup). Specimens of this moray obtained by Messrs. Jordan & Snyder in Japan in 1901 establish apparently beyond question the identity of Bloch's species, and its distinctness from both *petelli* and *ruppellii*.

[a] Lesson & Garnot, Voy. Coquille, 128, pl. 11, fig. 2, 1830.
[b] Lesson & Garnot, op. cit., 127, pl. 11, fig. 1.

ECHIDNA Forster.

33. Echidna polyzona (Richardson).

Muræna polyzona Richardson, Voy. Sulphur, Ichth., III, 1845, 112, pl. 55, fig. 11-14; no locality.
Echidna zonophæa Jordan & Evermann, Bul. U. S. Fish Comm., XXII, 1902, 167. Ibid., XXIII, pt. I, 1903, 109, pl. 21; Honolulu
Echidna vincta Jenkins, ibid., XXII, 1902, 429; Hawaii.
Echidna obscura Jenkins, ibid., XXII, 1902, 430, fig. 11; Honolulu.
Echidna psalion Jenkins, ibid., XXII, 1902, 431, fig. 12; Honolulu.
(?) *Echidna leihala* Jenkins, ibid., XXII, 1902, 428, fig. 9 (body not barred except at tip of tail).
(?) *Pœcilophis tritor* Vaillant & Sauvage, Rec. et Mag. Zool. (3), III, 287, 1875; Hawaii. Not barred.

Adults (*E. zonophæa*) have the interspaces between the 24 or 25 broad rich brown bands more or less broken up by mottlings, the plain (white?) interspaces appearing only on the tail. Young specimens have both the bands and the interspaces plain. The cross bands are obsolete on the belly. Life colors of young, white and dark brown; of adults,[a] brown of different shades, and golden yellow.

Crabs were found in the stomach of a large specimen.

Three specimens from Calayan, one 21 inches long and two under 5 inches. The numerous synonyms of this species seem to represent color variations, chiefly in young specimens. All of the nominal species have the white band on the snout as originally figured by Sir John Richardson.

34. Echidna nebulosa (Ahl).

Ground color cream in life, regularly marked with large stellate blotches of dark brown, with smaller spots of light yellow; nasal tubes orange.

One specimen from Calayan, 14 inches long.

Family MORINGUIDÆ.

MORINGUA Gray.

35. Moringua abbreviata (Bleeker).

One specimen from Ticao Island, 8 inches long.

Family CYPRINIDÆ.

BARBODES Bleeker.

36. Barbodes hemictenus Jordan & Richardson, new species.

Body moderately elongate, compressed, the back elevated, its highest point being at front of dorsal fin; head 3.60; depth 3; width of body 1.6 in head; depth of caudal peduncle 2 in head; dorsal III, 8; anal II, 6; scales 4½ or 5½–24–2½; scales before dorsal 9; snout 3.3 in head; eye 3.9; maxillary 3.6, reaching scarcely to front of orbit; interorbital distance 2.5 in head; mouth subterminal, very little oblique, the lips thin, the lower jaw overhung by the upper lip; upper jaw protractile; 2 barbels at each angle of upper jaw, the longest reaching to posterior margin of preopercle; nostrils separated by a small flap; head without tubercles or conspicuous pores; interorbital space gently convex; gill-membranes united to the isthmus at a point directly under the angle of the preopercle, the breadth of the isthmus about equal to diameter of eye; teeth, 2, 3, 4, or 5–4 or 5, 3, 2, slightly hooked, with narrow grinding surface; tongue adnate; origin of dorsal over third ray of ventrals, slightly nearer base of caudal than end of snout; dorsal base 1.8 in head; third dorsal spine enlarged, moderately strong, 1.2 in head, rather weakly serrated along the posterior edge of its outer half; anal equidistant between base of ventrals and base of caudal; anal base 2.8 in head; pectoral 1.25, weakly falcate, reaching within about one pupil's length of base of ventrals; ventrals 1.5, within one eye-length or less of vent; caudal forked, its middle rays but little less than half the length of its outer; scales large, cycloid; a single elevated range of scales along each side of base of dorsal and anal; accessory scale of ventral pointed, as long as eye; lateral line complete, decurved at middle, where its distance from base of ventral fin is nearly exactly twice its distance from the mid-dorsal line.

Color in spirits olivaceous, darker above; a dark lateral stripe, wider than pupil, reaching from upper corner of gill-opening to just above middle of base of caudal fin; a conspicuous roundish black spot, as large as eye, at middle of tip of caudal peduncle, immediately in front of base of caudal fin;

[a] The accuracy of Bloch's figure of *Gymnothorax reticularis* was affirmed by Doctor Günther more than thirty years ago (Cat., II, 106) and the relationships of the three species *reticularis*, *petelli*, and *ruppellii* outlined essentially as above.

an indistinct dark blotch on each side of front of dorsal fin, extending a very little on the base of the fin; all of the fins faintly marked with dusky in the rays; none of the fins dark edged.

Of this species we have five specimens, 3 to 4 inches long, from Mindoro Island. The type is no. 20213, Stanford University; cotypes are no. 61685, U. S. National Museum. One of the specimens was taken at Camp Balete, Rio Baco, Mindoro. The exact locality for the others is not recorded, the label reading merely "Mindoro Island."

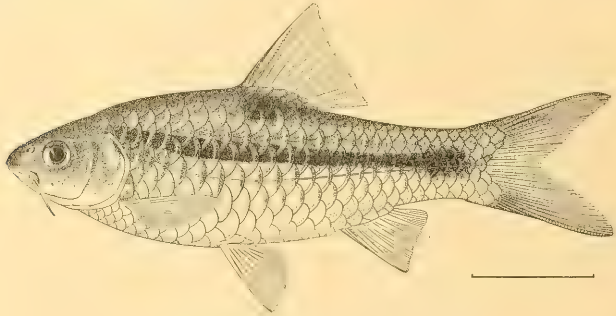


FIG. 5.—Barbodes hemictenus, new species. Type.

This species is near *Barbodes maculatus* Cuvier & Valenciennes (?=*B. binotatus* C. & V.), but seems to differ in its slenderer third dorsal spine, with weaker and fewer serratures, and in coloration. Specimens from Sumatra identified as *Barbodes maculatus* by Mr. Fowler agree with Bleeker's figure of the species in having the third dorsal spine strongly serrate to its base, in having the dorsal and caudal blotch indistinct, and in lacking a lateral body stripe. Mr. Fowler's specimens have the dorsal and anal distinctly tipped with dusky, which is lacking in our specimens and in Bleeker's figure of *Barbodes maculatus*.

(ἥμι, half; κτείς, κτενός, a comb.)

Family SILURIDÆ.

NETUMA Bleeker.

37. **Netuma thalassina** (Rüppell).

One specimen, 3.50 inches long, with Mr. McGregor's Philippine collection, but without exact locality label.

Family PLOTOSIDÆ.

PLOTOSUS Lacépède.

38. **Plotosus anguillaris** (Bloch).

Two examples from Cuyo, 5 inches long.

Family BELONIDÆ.

TYLOSURUS Cocco.

39. **Tylosurus caudimaculatus** (Cuvier).

One specimen from Iloilo, 9 inches long.

40. **Tylosurus giganteus** (Schlegel). *Batalay.*

Depth 3.20 in snout; head 3.15; snout 4.75; eye 2.50 in postorbital part of head; dorsal 20; anal I, 21; dorsal inserted over third ray of anal; a slight caudal keel; no teeth on vomer; breadth of body .80 of depth.

One specimen from Manila, 15 inches long, and one from Iloilo, 7 inches.

41. Tylosurus leiurus Bleeker.

Depth 12 in body without head and snout; eye in postorbital part of head 2.70; dorsal 18; anal 24; dorsal inserted over seventh ray of anal; breadth of body .66 its depth; no caudal keel.

One specimen from Aparri, about 15 inches long.

HEMIRAMPHUS Cuvier.

42. Hemiramphus marginatus (Forskål). *Buging.*

One example from Manila, 9 inches long.

43. Hemiramphus limbatus Cuvier & Valenciennes.

A specimen, 4 inches long, from Cuyo. Scales 53; head 2.70; lower jaw, beyond tip of upper, 5.50; ventrals inserted considerably nearer base of caudal than eye. In life silvery; a light green median line on side; top of head bright blue and green; beak with a small red tip.

44. Hemiramphus neglectus Bleeker.

A specimen, 4.50 inches long, from Aparri, agrees with Bleeker's description and figure of this species. It has scales 51; head 2.70; lower jaw, beyond tip of upper, 5.75; ventrals equidistant between base of caudal and front of pupil; teeth tricuspid; each side with a narrow silvery band, about as wide as a scale.

Doctor Günther considers this species to be identical with *H. unifasciatus* from the tropical Atlantic.

Family EXOCŒTIDÆ.

PAREXOCŒTUS Bleeker.

45. Parexocœtus mento (Cuvier & Valenciennes).

Depth 4.60; head 3.75; eye 2.60 in head; dorsal 10; anal 11; pectoral half of total length without caudal. Color in life: Lower half silvery white; deep blue black above, changing to deep blue on upper part of sides, the color of which is sharply separated from the lower silvery color; pectoral white, finely speckled with dusky; dorsal dusky at tip.

Five specimens from Manila, 4 inches long.

CYPSELURUS Swainson.

46. Cypselurus spilonopterus (Bleeker).

Depth 5; head 4.40; eye 3; dorsal 12; anal 9; pectoral reaching beyond middle of anal.

A single specimen, 6 inches long, taken at sea off the west coast of Negros.

Family ATHERINIDÆ.

ATHERINA Linnæus.

47. Atherina (?) lacunosa Forster.

A specimen, 2.75 inches long, from Iloilo has the head 3.75; depth 4.3; eye 2.25; snout 4; interorbital 2.75; maxillary 2.30; dorsal V–I, 9; anal 13; scales 38–6; origin of spinous dorsal slightly nearer anal than base of ventrals; vent a pupil's length in front of tips of ventrals; in spirits straw-colored, with a silvery side stripe as wide as pupil; no trace of dusky color on pectorals.

This specimen seems to have the depth slightly greater and the scales fewer than the specimens recently recorded under this name by Evermann & Seale. We do not think it likely that the two are different. We are by no means certain of the identity of Forster's *A. lacunosa*. It is probable that the name *lacunosa* should replace *pinguis*, applied by Lacépède to specimens with a black-tipped pectoral. In such a case a new name would need to be supplied for the specimens from the Philippines. We have a specimen of an *Atherina* (labeled *lacunosa*) from Sydney, Australia, collected by Dr. D. H. Campbell, which corresponds well with the description of *Atherina pinguis*. It has the depth 4.6, scales 42, and a distinctly black-tipped pectoral. It is evidently distinct from our specimens from the Philippines and is with little doubt the *A. pinguis* of Lacépède.

48. Atherina panatela Jordan & Richardson, new species.

Head 4.25; depth 6.8; greatest width nearly equal to greatest depth, the body being subcylindrical, but the back broader and flatter than the belly; head as wide as deep; eye 3.1; snout 3.75; interorbital space equal to eye, flat; maxillary equal to nose, its tip under anterior margin of orbit; gillrakers 23

on lower limb of first gill-arch; teeth in upper jaw minute, in an imperfect band, with an irregular outer row, larger than the rest; teeth in lower jaw scarcely appreciable; vomer and palatines with patches of minute teeth; dorsal VI–I, 9; anal I, 11; scales 38–6; origin of spinous dorsal over nineteenth scale of lateral line; base of soft dorsal 2.60 in head; base of anal 2; longest rays of soft dorsal and anal equal to eye; pectoral 1.66 in head; axillary scale three-fifths of length of pectoral; ventral 2.2; caudal forked. its middle rays half the length of the outer; 19 rows of scales in front of spinous dorsal; margins of scales entire; vent nearer base of ventrals than anal.

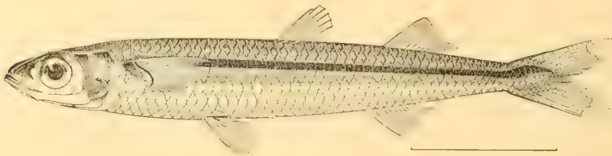


FIG. 6.—Atherina panatela, new species. Type.

Color in spirits dark straw; scales of back and sides with dark punctulations, forming a more or less distinct dark edge, or a submarginal dark line; each scale in third row from mid-dorsal row with a roundish black spot behind its center and just in front of an abrupt convexity in the submarginal dark line; middle of side traversed by a blackish (silvery?) band of a width equal to that of a scale; belly paler straw; top of nose, interorbital edges, and opercles blackish.

Known from a single specimen, the type, 4 inches long, no. 20203, Stanford University, from Calayan Island.

This species is close to *Atherina uisila* Jordan & Seale, from Samoa, but the position of the vent is different and the scales are smaller. In *A. uisila* the vent is nearer the base of the anal than the insertion of the ventrals, while in the present species it is nearer the ventral base.[a]

(*Panatela*, Spanish, the name of a long and slender cigar.)

Family MUGILIDÆ.

MUGIL Linnæus.

49. Mugil cephalus Linnæus.

One example, 6 inches long, from Calayan.

LIZA Jordan & Swain.

50. Liza troscheli (Bleeker).

A specimen each, 3.50 inches long, from Lubang and Aparri, and two specimens from Iloilo, 3 inches.

51. Liza oligolepis (Bleeker).

One specimen, 4 inches long, from Iloilo. Scales 26; anal III, 9; tip of maxillary hidden when mouth is closed.

ÆSCHRICHTHYS Macleay.

52. Æschrichthys goldiei Macleay. *Banac.*

Æschrichthys goldiei Macleay, Proc. Linn. Soc. N. S. Wales, 1883, 5, fig. 1 and 2; Goldie River, New Guinea.

One fine specimen 7 inches long and two between 4 and 5 inches from Mindoro Island. The genus *Æschrichthys* is easily recognized by the transverse groove at the back of the mandibles and the

[a] While the extremes of a series of species of the genus *Atherina* differ widely in the position of the vent, we find such complete intergradation that it is impossible to make use of this feature as a generic distinction. In five species before us, all of which have the vent situated behind the tips of the ventrals, the position varies as follows: (1) Exactly halfway between base of anal and base of ventrals, *tsurugæ;* (2) slightly nearer anal than ventral base, *uisila;* (3) slightly nearer ventral than anal base, *panatela;* (4) much nearer anal than ventral base, being almost equidistant between tips of ventrals and base of anal, *hepsetus* and *mochon.*

In five species which have the vent in front of tips of ventrals its different positions are as follows: (1) Barely in front of tips of ventrals, *insularum;* (2) one pupil-length in front of ventral tips, *bleekeri, pinguis,* and (?) *lacunosa;* (3) one eye-length in front of tips of ventrals, *woodwardi.*

smooth, toothless lower jaws. Our specimens doubtless came from fresh water, though this is not stated on the locality label.

Family SPHYRÆNIDÆ.

SPHYRÆNA Linnæus.

53. **Sphyræna jello** Cuvier & Valenciennes.

One specimen, 4 inches long, badly broken, from Iloilo.

54. (?) **Sphyræna commersonii** Cuvier & Valenciennes.

A specimen, 6 inches long, from Aparri, agreeing with *S. snodgrassi*, from Honolulu, Hawaii, in every respect except that there is a slight tentacle at tip of chin. Scales 80; head 2.80; depth 7.50; nose 2.20; eye 2.70 in snout; maxillary 2.25, not reaching front of eye; opercle with a single flexible point; sides with about 12 indistinct cross bands.

From *S. commersonii* as understood by Günther and Day, this specimen differs in its shorter maxillary. We are not certain that it is possible to determine satisfactorily what species was meant by Cuvier & Valenciennes in their original description of *S. commersonii*. Lacépède's figure of "*le Sphyrène chinoise*," on which the original description of Cuvier & Valenciennes was in part based, is poor to the point of wretchedness.

Family POLYNEMIDÆ.

POLYDACTYLUS Rafinesque.

55. **Polydactylus zophomus** Jordan & McGregor.

Polydactylus zophomus Jordan & McGregor, in Jordan & Seale, Bul. U. S. Fish Comm., XXVI, 1906, p. 11, fig. 4; Cavite, P. I.

Two examples, 5 inches long, from Manila, and one from Iloilo, 3 inches. In life white, with metallic golden and green reflections; dorsal and caudal dusky pale greenish; pectoral, ventral, and anal dusky, with wash of yellow; a dusky blotch behind upper margin of opercle.

56. **Polydactylus tetradactylus** (Shaw). *Mamalay*.

Two specimens, 4.50 inches long, from Manila.

Family FISTULARIIDÆ.

FISTULARIA Linnæus.

57. **Fistularia petimba** Lacépède. *Torotot*.

A specimen, 10 inches long, from Cuyo, and one from Lubang, 9 inches. In life dark greenish; under side of head and a line along belly to vent white.

58. **Fistularia serrata** Cuvier.

Two specimens, 6 to 7 inches, from Manila. In life light brown above and white below.

Family CENTRISCIDÆ.

ÆOLISCUS Jordan & Starks.

59. **Æoliscus strigatus** (Günther).

Seventeen specimens from Cagayancillo, 4 to 5 inches long.

Family SYNGNATHIDÆ.

CORYTHROICHTHYS Kaup.

60. **Corythroichthys spicifer** (Kaup).

Five specimens, 4 to 5.50 inches long, from Aparri.

CŒLONOTUS Peters.

61. **Cœlonotus leiaspis** (Bleeker).

One example from Mindoro Island, 6 inches long, and one from Sibuyan, 4.50 inches. These have the dorsal rays 55, situated on 13 rings, 4 of which belong to the body; body rings 17; tail rings 31; body smooth and rounded except for the dorsal ridges, on which character, combined with the long dorsal fin, Kaup's genus *Cœlonotus* was founded. Doctor Günther's specimen of *C. leiaspis* had the dorsal fin standing on twelve rings.

DORYRHAMPHUS Kaup.

62. **Doryrhamphus macgregori** Jordan & Richardson, new species.

Head 5.2 in length without caudal, greatest depth of body equal to length of postorbital portion of head; length of tail less than body, equal to length of last 17 body rings; rings of trunk 19, of tail 22; dorsal rays 27; the base of the fin .80 of head; spines at edges of body rings evident, but not prominent; lateral line continuous, passing into the lower caudal edge; snout 1.25 times postorbital part of head, the eye twice in same distance; interorbital space concave; behind the eyes, on occiput and nape, an

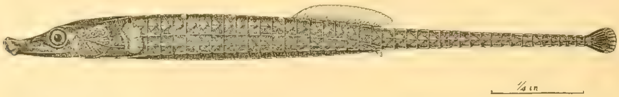


FIG. 7.—Doryrhamphus macgregori, new species. Type.

elevated median longitudinal ridge; lower sides of snout with two longitudinal raised edges, connected by numerous low and slight transverse keels; operculum with a slightly oblique median raised keel, from which radiate obliquely downward about 8 lesser raised lines; pectoral fin short, about equal to eye; color in spirits uniform dark brown; caudal with a whitish posterior edge.

Here described from a single specimen, 1.50 inches long, the type, no. 20202 U. S. National Museum, from Calayan. The specimen is probably a female.

Except for the much larger number of tail rings, this species seems closely to resemble *Doryrhamphus pleurotænia* (Günther).

GASTEROTOKEUS Heckel.

63. **Gasterotokeus biaculeatus** (Bloch). *Dumdam.*

Three examples from Cuyo, 6 and 7 inches long. General color in life grass green, finely speckled with pale blue; along side of head and tube some mottling of pink; eggs pale brown.

HIPPOCAMPUS Linnæus.

64. **Hippocampus kuda** Bleeker.

One example, 5 inches long, from Mindoro Island, agreeing with the specimen recorded by Jordan & Seale from Cavite. The specimens we have called *H. kuda* differ from *H. aterrimus* Jordan & Snyder in color, in their smoother body, with less prominent tubercles and without tentacles, in their longer snout and relatively longer body; and in the form of the coronet and lesser prominence of the head tubercles, which bear no tentacles. The length of the snout is nearly exactly equal to the distance from the front of the orbit to the anterior rim of the nuchal pore. In *H. aterrimus* the snout is shorter, though apparently variable in length, being never greater in our specimens than the distance from the posterior (not anterior) rim of the orbit to the nuchal pore. In *H. aterrimus* the depression on the top of the coronet is distinctly 5-sided, being bounded in front by two prominent points, while in *H. kuda* the rim of the depression is triangular, the two anterior points not being developed. The head and snout of *H. aterrimus* is striped with gray, in *H. kuda* speckled with black. The difference in relative length of the body, while difficult to measure, is evident to the eye on comparison of specimens of the same size. The specimens from southern Negros called *H. kuda* by Jordan & Seale are not that species,

but *H. aterrimus*. *Hippocampus kelloggi* Jordan & Snyder resembles *H. kuda*, but seems to be well distinguished by its smoother body, the spines of which are not enlarged at intervals. The coronet of *H. kelloggi* resembles that of *H. aterrimus*, rather than that of *H. kuda*, but the posterior point is double.

65. Hippocampus barbouri Jordan & Richardson, new species.

Head 1.25 in trunk; trunk in tail 2.50; depth 1.50 in head; body rings 11; tail rings 35; dorsal rays 19 or 20, the fin situated on 1½ body and 1½ tail rings; snout equal to distance from anterior margin of orbit to upper posterior corner of operculum; eye 2.50 in snout; supraorbital spines prominent, simple, acute; nasal spine sharp, directed obliquely forward; coronet moderately low, its depression bounded by five points, two anterior, one posterior, and two posterolateral; lower breast spines and cheek spines double on each side; spines of body prominent, larger at intervals, mostly acute, the larger ones sometimes rather rounded, but sharp-edged; spines of both head and body without tentacles.

FIG. 8.—Hippocampus barbouri, new species. Type.

Color light brown, the body more or less marbled and everywhere specked or reticulated with darker; snout and top of head crossed by numerous wavy lines of blackish; eye with similar wavy lines of dusky arranged radially; dorsal crossed submarginally by a prominent longitudinal dusky bar and at middle by a fainter one.

Three specimens, two males and one female, 4 inches long, from Cuyo. The type is no. 61683 U. S. National Museum; the cotypes no. 20205, Stanford University.

On the life colors of the specimens from Cuyo, Mr. McGregor writes as follows: "General color dark dull green, lighter and more yellowish on ventral surface; interorbital, sides of face, chin, throat, and upper part of neck clear light yellow, speckled with rows of fine black dots; on the tube the dots are in transverse rows, on the body the rows are broken up or wanting."

This species appears to be near *Hippocampus angustus*, described by Doctor Günther from Freycinet Harbor, Northwest Australia, but the body is deeper and the coloration is somewhat different.

This species is named for Thomas Barbour, of Harvard University, in recognition of his work on the fishes of the Indies.

Family HOLOCENTRIDÆ.

MYRIPRISTIS Cuvier.

66. Myripristis murdjan (Forskål). *Mangoe*.

One example, 4.50 inches long, from Cagayancillo. Color in life crimson; under parts strongly washed with rosy; a dark spot behind opercular spine and another in axil of pectoral; dorsal membranes light colored and without opaque white spots.

67. Holocentrus lacteoguttatus Cuvier & Valenciennes.

Holocentrum lacteoguttatum Cuvier & Valenciennes, Hist. Nat. Poiss., III, 1829, 214; Indian Ocean, Voy. Peron.
Holocentrum punctatissimum Cuvier & Valenciennes, op. cit., p. 215; Caroline Islands (et al. acct.).
Holocentrum stercus-muscarum Cuvier & Valenciennes, op. cit., VII, 1831, 503; Guam.

Holocentrum diploxiphus Günther, Proc. Zool. Soc., 1871, 660, pl. 60; Samoa Islands. Günther, Fische der Südsee, 97, 1873-75; Samoa, Marshall Islands, Tahiti, Paumotu, Aneiteum.
Holocentrus gracilispinis Fowler, Proc. Ac. Nat. Sci., Phila., 1904, 228; Honolulu.
Holocentrus gladispinis Fowler, ibid., p. 225; Tahiti.
Holocentrum argenteum Cuvier & Valenciennes, Hist. Nat. Poiss., VII, 502, 1831; New Guinea. Quoy & Gaimard, Voy. Astrolabe, Zool., 677, pl. XIV, fig. 2, 1834; New Guinea. Klunzinger, Fische des Rothen Meeres, I, 721, 1871; Red Sea.

A single specimen, 4 inches long, from Calayan. The back and sides are sparsely punctulated with minute specks. The spinous dorsal has a single row of opaque wedge-shaped white blotches.

A reexamination of the cotypes of *Holocentrus gracilispinis*, 18 in number, and ranging in size from 2 to 5.50 inches, seems to bear out Doctor Günther's view of the relations of part of the nominal species in this synonomy. The smaller specimens which are least faded are profusely covered with coffee-grain-like specks, like the specimens obtained by Jordan & Kellogg in Samoa, and the spinous dorsal has a series of conspicuous dusky blotches, above each of which is a diffused spot of opaque white. In more faded young specimens the coarser coffee-grainlike specks and the dark markings on the spinous dorsal have nearly disappeared. In specimens over 4 inches long, all of which are more or less faded, the side flecks and punctulations have almost completely disappeared in the largest, in which also the dark spots on the spinous dorsal are wanting. In one of these, 5 inches long, the opaque white blotches of the spinous dorsal, which take the place of the black and white spots of the young, form two series on the anterior part of the fin, as stated by Cuvier in the original description of *H. lacteoguttatum*. The *Holocentrum argenteum* of Cuvier & Valenciennes and of Quoy & Gaimard, described as without spots on the spinous dorsal, is doubtless not distinct from the present species, and has been so regarded by Doctor Klunzinger, who examined the types. The specimens recorded by Doctor Klunzinger from the Red Sea under the name *H. argenteum* had a row of opaque white spots on the spinous dorsal. The figure of *H. argenteum* by Quoy & Gaimard, in slight disagreement with their description, shows an opaquish blotch behind each dorsal spine.

68. Holocentrus ruber Forskål. *Sugac.*

One specimen, 5 inches long, from Cagayancillo, two from Cuyo, 2 inches, and one from Calayan, 1.50 inches. Side stripes black; outer soft ray of ventral blackish from base to tip. In life reddish with darker stripes; belly speckled; pectoral rays dark yellow; a dark blotch in upper portion of each spinous dorsal membrane. These specimens belong to the highly colored (coral reef) type called *Holocentrus praslin.*

A single specimen from Cuyo, 3 inches long, has the color much paler than in *H. praslin.* The ventrals are broadly tipped with blackish, not with the outer ray dusky and the rest pale, as in the form called *praslin.* This specimen evidently belongs to the form called *Holocentrus ruber* by authors.

69. Holocentrus microstomus Günther. *Sugac.*

One example, 4.50 inches long, from Cagayancillo. General color in life crimson; several longitudinal lines of pure white on sides; belly and chin white; flags of first dorsal crimson in membranes; a deeper colored blotch on first and second membrane; pectoral, ventral, caudal, and anal crimson.

70. Holocentrus sammara (Forskål). *Sugac.*

One specimen from Cagayancillo, 5 inches long. In life chiefly metallic silvery; scales with dusky spots forming nine longitudinal lines; head dark on top; opercle rosy; preopercle silvery; pectoral rosy; ventral white; first dorsal with deep red-brown spots in the membranes, and with an opaque (white ?) spot above and below; first three membranes of spinous dorsal each with a spot of dark crimson; second dorsal with first three rays and membranes dark red, the others yellow; caudal dark reddish brown above and below; middle yellow; third spine and first ray of anal red, the rest yellow.

Family SCOMBRIDÆ.

SCOMBER Linnæus.

71. Scomber microlepidotus Rüppell.

Six specimens from Manila, 4 to 6 inches long.

Family CARANGIDÆ.

SCOMBEROIDES Lacépède.

This genus is distinguished from the American genus *Oligoplites* by having teeth on the pterygoids, the maxillary broad behind (probably with well-developed supplemental bone), and more numerous dorsal spines. The jaws are without anterior canines as in *Oligoplites*.

It is clear from the statement of Cuvier & Valenciennes that all of their species, except the elongate *Chorinemus tol*, and the deep-bodied *Chorinemus farkhari*, possess the small-ovate evident scales usual in this genus. *Ch. tol* has slender, needle-like[a] or vermiculate scales as in the species of the American genus *Oligoplites*. The difference between the pointed ovoidal scales of *S. sancti-petri* and the needle-like scales of *S. tol* is, however, apparently much more a matter of degree than that between the scales of *sancti-petri* and the nearly orbicular ones of the two known species of the genus *Eleria*.

72. Scomberoides tol (Cuvier & Valenciennes). *Pipicao.*

Chorinemus tol Cuvier & Valenciennes, Hist. Nat. Poiss., VIII, 385, 1831; Pondicherry. Gunther, Cat. Fishes, II, 473, 1860.
Chorinemus moadetta, Day, Fishes India, 230, pl. LIII, fig. 1, 1876 (not of Cuvier & Valenciennes, which=*Scomberoides sancti-petri*, a species with pointed ovoidal scales, and with two rows of spots on each side).
Scomberoides toloo-parah, Jordan & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 13; Cavite, P. I. (not of Rüppell).

Two specimens from Manila, 6 and 8 inches. This species is well distinguished from others of its genus by its slender form and narrow needle-like scales. The specimens from Giran, Formosa, identified by Jordan & Evermann as *Scomberoides orientalis*, belong to *Scomberoides tol*.

73. Scomberoides toloo-parah Rüppell.

Two specimens, 10 inches long, from Cavite, taken by Dr. G. A. Lung, and recorded by Jordan & Seale as *Scomberoides tala*, evidently belong to this species of Rüppell. They are marked by the long vertical fingermark-like blotches on each side, the anterior three of which cross the lateral line. The scales are ovate, pointed behind as in *Scomberoides sancti-petri*. The teeth are in two rows in the lower jaw, those of the inner row somewhat enlarged in the back half of the jaw; there are no anterior canines. The *toloo parah* of Russell, with spots above lateral line, and the *Chorinemus toloo* of Cuvier & Valenciennes, though both poorly characterized, are probably identical and distinct from Rüppell's species. The name *toloo* is here consequently retained for the species with anterior canines in lower jaw and with narrow maxillaries, first adequately described by Day under that name, and in the present paper recorded as *Eleria tala*.

The specimens from Hawaii described by Jordan & Evermann as *Scomberoides toloo-parah* are referable rather to *Scomberoides sancti-petri*. The specimens taken in Samoa are properly identified as *Scomberoides sancti-petri*, of which *Chorinemus moadetta* Cuvier & Valenciennes is clearly a synonym. Klunzinger's *Chorinemus moadetta* is plainly *Scomberoides tol*.

ELERIA Jordan & Seale.

This genus, originally based on *Eleria philippina* Jordan & Seale (=*Chorinemus tala* of Day, but probably not *Chorinemus tala* of Cuvier & Valenciennes), is distinguished from *Scomberoides* by its narrow maxillaries (much as in the American genus *Oligoplites*), its nearly orbicular scales, and by the presence of outwardly directed canine teeth in the front of the lower jaw. Teeth are present on the pterygoids as in *Scomberoides*. Only the original types of *Eleria philippina* are known to us.

74. Eleria tala Cuvier & Valenciennes.

(?) *Scomber aculeatus* Bloch, Ichthyologia, pl. 336, 1797; no locality.
Chorinemus tala and *C. toloo* Cuvier & Valenciennes, Hist. Nat. Poiss., VII, p. 37, 1831; Malabar.

A single specimen, 6.50 inches long, from Manila, and one, 4.50 inches, from Iloilo. This species differs from *Eleria philippina* in having the teeth weaker and the four anterior canines of the lower jaw directed outward at each edge of the symphysis. In *Eleria philippina* there are also two pairs of anterior canines, the posterior pair being situated inside the jaw at the symphysis and directed upward. We here follow Day in identifying the present species with the *Chorinemus toloo* of Cuvier & Valen-

[a] On parts of the body these become quite short and are scarcely distinguishable in form from the scales of *S. sancti-petri*.

ciennes. *Chorinemus tala*, also described as having the teeth stronger in proportion than in *Ch. lysan*, is doubtless the same. Although the dentition was not adequately described by those authors, the agreement of the specimens with the remaining details of their description is satisfactory. Two small specimens from Cavite, collected by Doctor Lung and recorded by Jordan & Seale under the name of *Scomberoides tala*, belong to the present species. *Scomber aculeatus*, scantily described by Bloch, is nearer *Scomberoides tala* than any other form.

TRACHUROPS Gill.

75. **Trachurops crumenophthalma** (Bloch). *Matambaca* (="Cow-eye").

One specimen from Manila, 5 inches long, and one from Lubang, 3.50 inches.

MEGALASPIS Bleeker.

76. **Megalaspis cordyla** (Linnæus). *Ureles.*

One example from Manila, 7 inches.

CARANX Lacépède.

77. **Caranx forsteri** Cuvier & Valenciennes.

Four small specimens, 2.50 to 3.50 inches, one each from Lubang, Manila, Iloilo, and Cagayancillo.

78. **Caranx ignobilis** Forskål.

One example from Iloilo and one from Lubang, 3 inches long. This species is very close to *Caranx forsteri*, differing from it in having the breast naked except for a small central patch of scales.

79. **Caranx ire** Cuvier & Valenciennes. *Salay salay.*

One example from Manila, 6 inches long, and one from Iloilo, 2.50 inches.

80. **Caranx affinis** Rüppell.

A fine specimen, 6 inches long, from Cavite, taken by Doctor Lung, and recorded by Jordan & Seale as *Caranx hasseltii*, belongs to this species of Rüppell, which is distinguished from *Caranx leptolepis*, *djeddaba*, and *calla* by its more slender form. Depth 4.20 in total length, including caudal; lateral line becoming straight under seventh soft dorsal ray.

81. **Caranx leptolepis** Cuvier & Valenciennes.

A small specimen, 3 inches in length, taken at Cavite by Doctor Lung. The lateral line becomes straight under the twelfth dorsal ray. Depth 3.60 in total length, including caudal.

82. **Caranx calla** Cuvier & Valenciennes.

Four specimens, 3 inches long, from Manila and a single small specimen from Iloilo. This species is close to *Caranx djeddaba*, but the lower profile is more convex than the upper, and the lateral line becomes straight under the fourth or fifth soft dorsal ray. Depth 3.25 in total length. Four small specimens from Cavite, taken by Doctor Lung and recorded by Jordan & Seale as *Caranx nigripinnis*, belong to this species.

83. **Caranx djeddaba** (Forskål).

One example, 6 inches long, from Manila. The upper and lower profile are equally curved and the lateral line becomes straight under the second soft dorsal ray. Depth 3.60 in total length. Color in life, silvery white, washed with pale yellow along lateral line; caudal strongly lemon yellow, the upper fork edged with dusky; upper parts deep blue; snout brown; a black blotch on upper posterior edge of opercle; pectoral, anal, and ventrals pure white; dorsals edged with dusky.

84. **Caranx deani** Jordan & Seale.

A specimen 4 inches long, from Cavite, taken by Doctor Lung and recorded by Jordan & Seale as *Caranx nigripinnis* apparently belongs to this species.

85. **Caranx armatus** Forskål.

One specimen, 4 inches long, and one 2 inches, from Manila.

86. **Caranx altissimus** Jordan & Seale.

Three specimens, 3 to 4 inches long, from Manila.

Color in life, silvery white; a wash of pale blue on upper half; pectoral and caudal faintly washed with yellow; caudal edged with dusky; a small spot on posterior part of opercle, and another in axil of pectoral.

ALECTIS Rafinesque.

87. Alectis major Cuvier & Valenciennes.

Zeus gallus Bloch, Ichthyologia, taf. 192, fig. 1, 1786; East Indies. (Not of Linnaeus, which =*Selene vomer*.)
?*Zeus virescens* Lacépède, Hist. Nat. Poiss., IV, 583, 1803; *Atlantic, Mediterranean*, East Indies. (Description insufficient.)
Gallichthys major Cuvier & Valenciennes, Hist. Nat. Poiss., IX, 168, pl. 254, 1833; East Indies.
Scyris indica Rüppell, Atlas, 128, taf. 33, fig. 1, 1826; Red Sea.
Alectis ciliaris, Jordan & Seale, Bul. U. S. Bureau of Fisheries, XXVI, 1906 (1907), 14. Cavite, P. I. Jordan & Evermann, Proc. U. S. Nat. Mus., XXV, 1902, 338; Formosa. (Not *Zeus ciliaris* of Bloch.)

Seven specimens from Manila, 3.50 to 4.50 inches long.

Color in life, silvery white, with blue and bronze reflections, especially on lower half; upper half, dorsal, and anal washed with yellow; a dusky line from interorbital to dorsal, and along base of dorsal on each side; dorsal fin streamers and ventrals dusky brown; pectoral clear; caudal slightly washed with yellow.

Comparison of adult specimens of *Alectis major* recently received from Formosa with specimens of *Alectis ciliaris* of the same size obtained by Doctor Gilbert at Panama leaves no doubt that the two are distinct species. They are well distinguished in Rüppell's figures (Atlas, pl. 33, fig. 1 and 2) of *Blepharis fasciatus* (= *A. ciliaris*) and *Scyris indica* (= *A. major*). Bloch's figure of *Zeus ciliaris* shows the ventrals too long, but there is no serious reason for doubting that it is the same as *Blepharis fasciatus*, distinguished as it is from Bloch's *Zeus gallus* (= *Gallichthys major* C. & V.) by its convex profile, shorter nose, longer fin streamers, and basal blotch on dorsal fin.

Family MENIDÆ.

MENE Lacépède.

88. Mene maculata (Bloch). *Zapatero.*

One specimen from Manila, 5.50 inches long.

Family RACHYCENTRIDÆ.

RACHYCENTRON Kaup.

89. Rachycentron canadum (Linnæus).

(*Elacate pondicerriana* Cuvier & Valenciennes.)

One young specimen from Manila.

It appears that this species undergoes considerable changes in form and coloration with age. The example before us, which is 10 inches long, has the caudal scarcely emarginate, tipped both above and below with white. The median lateral band is nearly twice as wide as the eye, and prominent. The specimen agrees in all respects with Russell's figure, no. 153, called by him *Peddamottah*, and taken from a specimen 1 foot 5 inches long. An apparently excellent figure of the Atlantic form was published by Doctor Holbrook in his Ichthyology of South Carolina (pl. 14, fig. 2), evidently from an adult specimen, as the tail is deeply notched and without white edges. Doctor Holbrook had seen specimens as long as 4 feet. We do not know the length of the specimen figured by Jordan & Evermann (Fishes of North & Middle America, pl. 148, fig. 401). Professor Rüppell's figure of an adult specimen from the Red Sea (Neue Wirbelthiere, pl. 12, fig. 3) does not appear to differ essentially from the figures of Holbrook and Jordan & Evermann of the Atlantic form, except that the dusky lateral stripes are wanting, doubtless due to age. Rüppell's specimens were 2 to 2½ feet in length. Bloch's figure of *Scomber niger* was based on an old manuscript drawing by Prince Maurice of Nassau, and is extremely poor, although doubtless representing the present species.

Family TRICHIURIDÆ.

TRICHIURUS Linnæus.

90. Trichiurus haumela (Forskål).

One specimen, 15 inches long, and three under 9 inches, from Manila. Color in life silvery white; dorsal pale yellow, edged with dusky; a dusky line along base of dorsal on each side; pectoral pale yellow, speckled with dusky.

This species differs from *Trichiurus savala* Cuvier in its much larger eye, which is contained 2.50 in the snout. *Trichiurus savala* is stated by Doctor Günther, who had specimens, to have the eye 3.50 in snout and is so figured by Cuvier & Valenciennes. Specimens recorded by Jordan & Seale from Cavite as *T. savala* are not that species, but are *Trichiurus haumela.*

Family STROMATEIDÆ.

APOLECTUS Cuvier & Valenciennes.

91. **Apolectus niger** (Bloch).
Three specimens from Manila, 2.50 inches long.

Family EQUULIDÆ.

EQUULA Cuvier.

92. **Equula insidiator** (Bloch).
Four specimens from Manila, 3 inches long.

LEIOGNATHUS Lacépède.

93. **Leiognathus ensiferus** (Cuvier & Valenciennes).

Equula ensifera Cuvier & Valenciennes, Hist. Nat. Poiss., x, 66, 1835; Pondicherry.
(?)*Scomber edentulus* Bloch, Ichth., pl. 428, 1785; Tranquebar.
Equula dussumieri Cuvier & Valenciennes, Hist. Nat. Poiss., x, 77, pl. 283, 1835; Coromandel. Günther, Cat. Fishes, II, 500, 1860; Borneo. (Not *Leiognathus dussumieri* of Jordan & Seale, except in part, or of Evermann & Seale.)
? *Equula edentula*, Günther, Cat. Fishes, II, 498, 1860; in part.

Depth 1.80 (2.33 in total length); head 3.2 (4.16 in total length); nose short, rather deep, hardly equaling eye; eye 28 in head; nuchal spine straight, its length from the base of its median ridge 1½ times eye, the tip of the spine reaching much more than halfway from its base to the first dorsal spine; supraocular ridges distinctly convergent posteriorly; mandible very little concave; lower margin of preopercle with a few indistinct and discontinuous fine serratures; teeth evident; second dorsal spine broken off; ventral spine short, not more than ⅔ length of second anal spine; pectoral 1.25 in head; scales larger than in allied species of *Leiognathus*, about 22 series before origin of spinous dorsal; color silvery, bluish above; anterior rays and membranes of spinous dorsal with dusky tinge; axil of pectoral blackish; sides of muzzle rather heavily punctulated with blackish.

Color in life silvery; lateral line and edge of dorsal and anal bright lemon yellow; base of pectoral dusky, basal half of fin yellow; caudal washed with yellow, edged with dusky; sides of snout dusky.

This species is most readily distinguished from those we have called *Leiognathus caballus* and *coma* by its less concave mandible and its larger scales. We do not believe that the *Equula ensifera* and *E. dussumieri* of Cuvier & Valenciennes are distinct, those authors stating that *E. dussumieri* is merely a little more oblong and has the second dorsal spine a little shorter. Cuvier's characterization of *Equula ensifera* by its second dorsal spine, which is said to be "compressed, broad, and curved like the blade of a saber," applies more or less equally to any of the three allied species with which we are here concerned. If there is any difference in this respect, the specimens we have called *L. caballus* have the second dorsal spine broadest and most saber-like of the three species. But *E. caballa* is explicitly contrasted by Cuvier & Valenciennes with *E. ensifera* and (by implication) with *E. dussumieri*, as a species differing from both in its longer head and its strongly concave mandibular outline. We are not at all certain of the identity of Bloch's *Scomber edentulus*, which is evidently both poorly described and poorly figured. It seems to us most likely that it is the fish we have here called *Leiognathus coma*, although we doubt if it is possible satisfactorily to determine it without examination of the type. Valenciennes's verification of the synonomy of *S. edentulus* with Cuvier's *E. ensifera* we can not admit to hold, this having apparently gone little, if any, further than an examination of the teeth, in order to controvert Lacépède's position in establishing his genus *Leiognathus*. The *Leiognathus argenteus* of Lacépède was founded on Bloch's description in the entire absence of specimens. The present species seems not to have been known to Russell.

Two specimens, 2.75 and 4 inches long, from Manila, and one from Iloilo, 1.75 inches. Three young specimens, 2.50 inches long, from Cavite, taken by Doctor Lung and recorded by Jordan & Seale

as *Leiognathus dussumieri* are also of this species. The *Leiognathus dussumieri* of Evermann & Seale, which has the "spine-shaped crest on nuchal region not reaching halfway to base of first dorsal spine," is evidently not this species, but probably *Leiognathus coma.*

94. Leiognathus caballa (Cuvier & Valenciennes).

Equula caballa Cuvier & Valenciennes, Hist. Nat. Poiss., x. 73, 1835; Indian Ocean and Red Sea. Günther, Cat. Fishes, II, 499, 1860.
(?)*Scomber equula* Forskål, Descr. Animal., 58, 1775; Red Sea.
Totah-Karah, Russell, Fishes Coromandel, pl. 62, 1803.
Leiognathus dussumieri, Jordan & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 15; Cavite, P. I. (in part only, some of the specimens being *L. ensifera;* not *Equula dussumieri* of Cuvier & Valenciennes, or of Günther, or of Evermann & Seale).
Leiognathus edentulus, Evermann & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 69; San Fabian, P. I. (not at all certainly the *Scomber edentulus* of Bloch).

Depth 1.66 (2.16 to 2.25 in total length); head 3 (3.66 to 3.75 in total length); nose longer and less deep than in *L. ensifera*, about 1.2 times eye; eye 3.1 in head; nuchal spine strongly curved, and the profile prominently concave in front of its base; length of the median nuchal ridge fully 1.5 times eye, the tip of the spine reaching considerably more than halfway to base of first dorsal spine; supraocular ridges nearly straight, or slightly divergent posteriorly; lower outline of mandible very strongly concave, lower margin of preopercle scarcely serrated; teeth minute; second dorsal spine broad and sharp-edged anteriorly, its length about 1.4 in head; ventral spine .75 of length of second anal spine; pectoral 1.25 in head; scales smaller than in *L. ensifera*, about 32 series in front of spinous dorsal; color in spirits silvery, bluish above; dorsal and caudal faintly edged with dusky; axil of pectoral blackish; sides of muzzle weakly punctulated with blackish. In life the anal fin is washed with chrome yellow.

This species may be known by its long head, very deep body, highly arched back and deeply concave profile, and its strongly concave mandibular outline. It is well described by Cuvier & Valenciennes. Our specimens, ranging in size up to 5.50 inches, give the head measurement as stated by the authors of the Histoire Naturelle de Poissons and quoted with interrogation by Doctor Günther. Specimens of *L. ensiferus* and *L. coma* invariably have the head distinctly shorter. It is likely that Forskål's *Scomber equula*, "*5 poll. long, 3 poll. latum; labium—inferius curvum, retusum,*" is this species, and that the name *equula* should replace *caballa.*

We have two examples, 4.50 inches long, from Manila; one from Iloilo, 2.50 inches, and one from Aparri, 2.50 inches. Three specimens from Cavite, 1.50 to 5.50 inches long, recorded by Jordan & Seale as *Leiognathus dussumieri*, belong to this species; as also one from Keerun, Formosa, 2.50 inches long, from among specimens recorded by Jordan & Evermann as *Leiognathus splendens;* and one of the same size from southern Negros, recorded by Jordan & Seale under the latter name.

95. Leiognathus coma (Cuvier & Valenciennes).

Komah-Karah, Russell, Fishes Coromandel, pl. 63.
Equula coma Cuvier & Valenciennes, Hist. Nat. Poiss , x, 76, 1835 (after Russell).
Leiognathus dussumieri, Evermann & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 67; San Fabian, P. I. (not *Equula dussumieri* of Cuvier & Valenciennes or of Günther).
(?)*Scomber edentulus* Bloch, Ichth., pl. 428, 1785; Tranquebar.

Depth 1.9 (2.45 in total length); head 3.2 (4 in total length); nose 1.2 times eye, noticeably less deep than in *L. caballa;* eye 3.3; nuchal spine short and somewhat curved, its length not greater than eye, the tip of the spine reaching less than halfway from the base of its median ridge to the base of the first dorsal spine; supraocular ridges convergent posteriorly; mandibular outline slightly less concave than in *L. caballa;* lower margin of preopercle strongly serrate; teeth distinct; second dorsal spine longer than head; second anal spine 1.4 in head; ventral spine .6 of second anal spine; pectoral pointed, 1.3 in head; scales very small, about 35 series in front of origin of spinous dorsal; color as in *L. caballa*, but with the sides and front of muzzle with more black, and with 6 or 8 indistinct transverse bands of dusky between lateral line and dorsal outline.

We have little doubt that our specimens, one from Iloilo and two from Manila, 3 inches long, are the *Komah-Karah* of Russell. They differ from those that we have called *L. caballa* in their distinctly more slender body, slightly smaller scales, slightly less concave profile and mandibular outline, and much shorter nuchal ridge. The shortness of the nuchal ridge alone will separate them at once from *Leiognathus ensiferus, caballa, splendens,* and *fasciatus,* the two last species being, however, well enough distinguished by other characters. In form *Leiognathus coma* very much resembles *L. nuchalis,* which approaches *L. coma* in the shortness of its nuchal spine. But *L. nuchalis* is easily separated

by its nuchal blotch and much shorter second dorsal and second anal spine. We have no doubt that the *Leiognathus dussumieri* of Evermann & Seale, said to have the nuchal spine reaching less than halfway to base of first dorsal spine, is this species.

It is not impossible that this may be the *Scomber edentulus* of Bloch. Both our *L. coma* and Bloch's species have transverse bands, which are lacking in our specimens of *L. ensiferus* and *L. caballa*. Of the three species *L. coma* also agrees with Bloch's figure most nearly in its slenderness of form. Cuvier's figure of *Equula dussumieri* (=*ensiferus*), however, also shows indistinct cross bands, and it is barely possible that *Scomber edentulus* is the same as *L. ensiferus*. But the evident poorness of Bloch's figure and utter lack of specific characterization in his description stand badly in the way of any satisfactory conclusion.

96. **Leiognathus splendens** (Cuvier).

One specimen from Aparri, 2.50 inches long, and one from Manila, 2.25 inches.

GAZZA Rüppell.

97. **Gazza minuta** (Bloch).

Two examples, 3 inches long, from Manila; one from Lubang, 2.50 inches; and one from Iloilo, 2.50 inches.

Family PEMPHERIDÆ.

PEMPHERIS Cuvier.

98. **Pempheris oualensis** Cuvier & Valenciennes.

Two examples, 5.50 inches long, from Calayan.

Family KUHLIIDÆ.

KUHLIA Gill.

99. **Kuhlia rupestris** (Lacépède).

A single example, 7 inches in length, from Mindoro Island.

100. **Kuhlia marginata** (Cuvier & Valenciennes). *Damagan.*

Three specimens from Mindoro Island, 4 to 7 inches long, and one 4 inches long from Aparri. One of the smaller Mindoro specimens was taken from the Rio Baco, above tide, at Camp Balete.

Family APOGONICHTHYIDÆ.

AMIA Gronow.

101. **Amia lateralis** (Valenciennes).

Dorsal VI-I, 9; anal II, 8; a narrow black line on each side from opercle to base of caudal, just before which is a small round black spot. Bleeker's *Apogon ceramensis*, from Ceram, and Day's specimens from Nicobars, called by him *Apogon ceramensis*, appear to be in no way distinguishable from the present species. The types of Valenciennes were from Vanicolo.

Of this species we have one specimen, 3 inches long, from Cuyo.

102. **Amia novæ-guineæ** (Valenciennes).

A single specimen, 2 inches long, from Iloilo.

103. **Amia novemfasciata** (Cuvier & Valenciennes).

Of this well-marked species we have four specimens from Calayan, 3 to 3.50 inches long, and a single specimen each from Cuyo and Ticao Island.

104. **Amia quadrifasciata** (Cuvier & Valenciennes).

Three specimens from Manila, 2.25 to 3 inches. Color in life silvery, with blue and green reflections; pectoral clear; other fins reddish; caudal with a dusky longitudinal line through middle.

105. **Amia hyalosoma** (Bleeker).

Two specimens from Mindoro Island, 4.50 inches long, and one from Calayan (from brackish water near stream mouth), 5 inches. These specimens agree perfectly with the description and figure of this

species published by Day. Bleeker fails to describe and omits from his figure the black blotch between the second and third dorsal spines. There is, however, scant reason for supposing that his and Day's specimens are different. *Amia jenkinsi* Evermann & Seale differs from the present species in its shorter maxillary. Life colors of Calayan specimen silvery, dusky above; a large circular dusky spot on caudal peduncle; a small dusky mark on each side above posterior base of anal.

106. Amia kalloptera (Bleeker).

A single specimen 3 inches long, from Fuga Island, evidently belongs to this species. There is an indistinct dusky lateral band, above and below which is a faint light border. At the base of the caudal fin, above the lateral line, is a black blotch as large as the pupil. There are oblique black blotches on the first four membranes of the spinous dorsal. Both soft dorsal and anal are barred across the base, and the soft dorsal is also margined with dusky. The caudal is black-edged above and below, and the membrane between the first and second rays of the ventral is blackish.

MIONORUS Krefft.

107. Mionorus glaga (Bleeker).

Four specimens, 2 to 3 inches, from Manila. Color in life silvery, with green reflections; dorsal and caudal edged with dusky; ventral and anal washed with yellow; pectoral faintly washed with red.

APOGONICHTHYS Bleeker.

108. Apogonichthys fo (Jordan & Seale).

A single example, 2 inches long, from Iloilo.

The original type of *Apogonichthys* Bleeker is *A. perdix* Bleeker (Floris). This species has an incomplete lateral line, an entire preopercle and teeth on the palatines. The genus *Apogonichthys* is therefore the same as *Foa*, and *Fowleria* (*aurita*) is generically distinct.

Family AMBASSIDÆ.

AMBASSIS Cuvier.

109. Ambassis urotænia Bleeker (not *Ambassis urotænia* of Day).

Four specimens, 3 to 4 inches long, from Calayan, in a brackish estuary, and one example from Iloilo, 4 inches. Lateral line not interrupted.

110. Ambassis kopsi (Bleeker).

A single specimen, 2.50 inches long, from Iloilo.

PRIOPIS Kuhl & Van Hasselt.

111. Priopis interrupta (Bleeker).

Two specimens from Mindoro Island, 2.50 and 3 inches long, and one from Cuyo, 2 inches.

112. Priopis buruensis (Bleeker).

Two specimens from Aparri, 2.75 and 3.50 inches long, we refer with some hesitation to this species. They are of slightly slenderer form than the specimens we have called *Priopis interrupta*, and the second dorsal spine is not so long, the specimens in these respects agreeing with those from Cavite, called *buruensis* by Jordan & Seale. In both the present specimens and in those here recorded as *Priopis interrupta* the interopercle has from 3 to 5 small denticulations in front of its posterior angle. Doctor Bleeker states (Key, Revision *Apogonini*) that the interopercle is smooth or has only a single denticulation in *Ambassis buruensis*. The two forms, as they are represented in our own specimens, are evidently very closely related, and may not be really different.

Family SERRANIDÆ.

NIPHON Cuvier & Valenciennes.

113. Niphon spinosus Cuvier & Valenciennes.

A single specimen, 3.50 inches long, from Cuyo.

Color in life pale silvery blue; fins light salmon; caudal light yellow at base.

CENTROGENYS Richardson.

(*Myriodon* Brisout de Barneville; *Gennadius* Jordan & Seale.)

114. Centrogenys vaigiensis (Quoy & Gaimard).

Scorpæna vaigienis Quoy & Gaimard, Voy. Uranie, Zool., 324, pl. LVIII, fig. 1, 1824; Waigiou.
Centrogenys waigiensis, Bleeker, Atlas, VII, 68, pl. CCXCVII, fig. 1, 1876; East Indies.
Sebastes stoliczkæ Day, Fish. Ind., 148, pl. XXXVI, fig. 1, 1877; Nicobars (name corrected in addenda to *Myriodon waigiensis*).
Gennadius stoliczæ, Jordan & Seale, Bul. U. S. Bureau of Fisheries, XXVI, 1906 (1907), 37; Panay, P. I.
Centrogenys vaigiensis, Boulenger, Cat., 147, 1895; Singapore to Philippines and Australia.

One specimen from Cuyo, 3.25 inches long. The original figure of this species by Quoy & Gaimard shows the lower pectoral rays unbranched.

VARIOLA Swainson.

115. Variola louti (Forskål).

A specimen, 9.50 inches long, from Calayan. Color in life dark red, spotted with darker red; terminal half of pectoral light yellow.

CEPHALOPHOLIS Bloch & Schneider.

116. Cephalopholis miniatus (Forskål).

One finely preserved specimen from Calayan, 7.50 inches long. In life bright scarlet, thickly spotted with dark blue.

117. Cephalopholis argus (Bloch). *Turnutulin.*

One example, 5.50 inches long, from Cagayancillo. Color in life dark brown, everywhere spotted with deep blue, each spot surrounded with black; spots most numerous on dorsal, caudal, and anal fins.

118. Cephalopholis leopardus (Lacépède).

A specimen, 6 inches long, from Calayan Island. Dorsal IX, 15; anal III, 9; scales 7–75–30; color apparently much faded; two dusky blotches on top of caudal peduncle; fins pale; caudal with two oblique converging dark bars behind. In life bright scarlet, with dusky along sides of dorsal.

EPINEPHELUS Bloch.

119. Epinephelus diacanthus (Cuvier & Valenciennes).

A specimen, 4 inches long, from Cuyo, and one 3 inches long from Cagayancillo, apparently belong to this species. Oblique body bands distinct. Teeth in two rows in anterior part of lower jaw.

120. Epinephelus megachir (Richardson).

Four specimens from Calayan, 3 to 3.50 inches long, conform more nearly to the description of this species than any other. The pectorals are noticeably longer than in other East Indian species of *Epinephelus*, though somewhat shorter than the head. The teeth are in two rows anteriorly in the lower jaw and in a single row behind the anterior third of the jaw. Body, head, and fins are everywhere closely spotted, the spots on the body being for the most part roundish and larger in size than the pupil. There are no cross bands.

121. Epinephelus nebulosus (Cuvier & Valenciennes).

Depth 3.20; head 2.60; dorsal XI, 16; anal III, 8; scales 17–98–42; snout 4.60, equaling eye; eye 4.60; interorbital space 1.6 in eye; lower jaw slightly projecting; maxillary 2.30 in head, scarcely extending to the vertical from posterior border of orbit; teeth in two series in lower jaw; canines moderate; preopercular angle with 5 or 6 teeth larger than the rest; middle opercular spine nearer lower than upper, the lower spine scarcely as far back as upper; opercular flap pointed; head covered with cycloid scales; maxillary not scaly; gill-rakers 15 on the lower part of the anterior arch; dorsal origin over base of pectoral; longest dorsal spine shorter than soft rays; pectoral 1.6 in head; ventral 1.9, not quite to vent; third anal spine scarcely as long as second; caudal rounded; scales of middle portion of sides ctenoid, those of belly and breast and above lateral line on anterior half of body cycloid.

Color in spirits dark brownish, each side with numerous large circular pale spots, nearly as large as eye, and each encircled by a more or less continuous black border; two similar black-bordered spots on the opercle; three dark stripes radiating from the eye backward across the cheek; two zigzag black lines, bordering a pale interstripe, passing downward and backward from back of maxillary; a similar

pale cross band, bordered with blackish, on each side of chin midway of length of mandible; dorsal dusky, slightly mottled with lighter, especially anteriorly on soft dorsal; caudal blackish, with a narrow white edge and with a few small whitish spots posteriorly; anal blackish, with pale edge; ventrals dusky; outer two-thirds of pectorals blackish, with pale outer edge and with three pale crossbars, the two anterior ones incomplete, being represented in the middle of the fin by two or three separated round pale spots.

A single young specimen, 3.50 inches long, from Aparri, agrees with the figure of Bleeker except in the coloration of the pectorals. Owing to its small size, we can not be certain that the specimen is not the young of Bloch's *Epinephelus brunneus*. Bloch's figure, however, shows a considerably different coloration. From Doctor Boulenger's redescription of *E. brunneus* from a half-grown individual from the Chinese Sea, our specimen differs in the following particulars: (1) In that the scales are largely ctenoid; (2) that the lower opercular spine is not as far back as the upper; (3) that the maxillary is not scaly; (4) that the third anal spine is shorter, rather than longer, than the second. It is difficult to compare the coloration, owing to the different age of the specimens and the lack of detail in Doctor Boulenger's description. *Serranus kawamebari* of Richardson (not Temminck & Schlegel), which is thought by Doctor Boulenger to be a synonym of *Epinephelus brunneus* was said by Sir John Richardson to have the pectorals colorless (size of specimen, 6 inches). Bloch's fish had the pectorals barred.

PLESIOPS Cuvier.

(*Pharopteryx* Rüppell.)

122. Plesiops nigricans (Rüppell).

Three examples, 5 inches long, from Calayan. Dorsal spines 12.

123. Plesiops melas (Bleeker).

Four specimens, 2 to 2.75 inches, from Calayan. Dorsal spines 11; body without blue spots or lines.

Family PRIACANTHIDÆ.

PRIACANTHUS Cuvier.

124. Priacanthus hamrur (Forskål).

One specimen, 9.50 inches long, from Calayan. Uniform light scarlet in life.

Family LUTIANIDÆ.

LUTIANUS (Bloch).

125. Lutianus argentimaculatus (Forskål).

A specimen, 7.50 inches long, from Calayan, in a brackish estuary; one 5 inches long from Camp Balete, Rio Baco, Mindoro, above tide; and one, 4 inches, from Iloilo. Life colors of Calayan specimen dark olive green above lateral line, below dark red, more or less spotted and blotched with silvery; a wavy line of dark blue green below eye; ventral and anal red, edged with white; pectoral red.

126. Lutianus kasmira (Forskål).

A single example, 5 inches long, from Fuga Island.

127. Lutianus lineatus (Quoy & Gaimard).

A specimen, 4 inches long, from Lubang, and one from Aparri, 3 inches.

128. Lutianus russelli (Bleeker). *Daragdarag.*

A specimen 3.50 inches long from Cuyo, and one of the same size from Iloilo. In life, dark greenish above lateral line; side and belly silvery; each side crossed by five light orange lines, the upper one short, the second extending from the eye to the large brown spot on lateral line beneath first dorsal ray; third and fourth extending from gill-opening to caudal; fifth from pectoral to caudal; pectoral white, the other fins washed with light orange; no dark spot at base of pectoral.

The identification of these specimens with this species of Bleeker is rendered possible only by the full description of the life colors by Mr. McGregor, all traces of the orange stripes having disappeared in the preserved specimens. We are not certain that *L. russelli* is distinct from *L. fulviflamma* (Forskål). The young specimens recorded from Cavite by Jordan & Seale as *Lutianus russelli* are not this species, but are more probably *L. quinquelineatus*.

129. Lutianus quinquelineatus (Bloch).

A specimen 3.50 inches long from Manila, and one yet smaller from Aparri, we refer with some hesitation to the present species. Scales 58; dorsal x, 14; anal III, 9; tongue with teeth; back of preopercle with an evident, but not deep, notch; each side with three dusky bands, the upper band extending from top of eye to end of spinous dorsal; second band proceeding from middle of eye backward, passing through a black fingermark-like blotch, bordered with pale, which lies half above and half below the lateral line, under the front part of the soft dorsal; a distinct black blotch on upper part of base of pectoral. The life colors of the Manila specimen are thus described by Mr. McGregor: Dusky green above; white below; three obscure dusky brown longitudinal bands on side, the middle one ending in a large black oblong spot under first dorsal rays; pectoral white; anal and ventral clear light yellow; dorsal and caudal dusky.

The presence of only 3 dusky stripes, instead of 5, which Doctor Day found in specimens as small as 6 inches, we think may be due to the still more youthful condition of our specimens. The occurrence of the dark spot at the base of the pectoral appears to be a distinctive character.

The specimens recorded by Jordan & Seale from Cavite as *Lutianus russelli* belong to the present species.

130. Nemipterus japonicus (Bloch).

A single specimen, 3.50 inches long, from Manila. In life silvery, with a rosy wash; about eight obsolescent longitudinal lines of pale yellow; a broad stripe of sulphur yellow along under surface from isthmus to caudal; dorsal and caudal tipped with deep rose; caudal with a line of chrome yellow along upper margin; pectoral pale rose; ventral white; anal white with two faint rosy lines.

Family THERAPONIDÆ.

THERAPON Cuvier.[a]

131. Therapon cancellatus (Cuvier & Valenciennes).

Two specimens from Mindoro Island, 5 and 6 inches in length.

132. Therapon quadrilineatus (Bloch).

Four specimens, 3 to 5 inches long, from Cuyo, Lubang, Iloilo, and Aparri. General color in life silvery white; a steely gloss on upper parts; four longitudinal lines of brown on each side, with an incomplete fifth stripe between the two upper ones, stopping under the second or third dorsal spine; dorsal clear, with a dark brown blotch between third and sixth spines; on each side a dusky predorsal blotch.

133. Therapon puta (Cuvier & Valenciennes).

One specimen from Iloilo and one from Manila, 3 and 4 inches long. Life colors of Manila specimen silvery, with a light bluish wash above; two dusky green bands extending full length of side, the first originating behind middle of eye and the second just above it; a large dusky blotch on spinous dorsal; anterior margin of soft dorsal greenish; four oblique dark green bands on caudal, two on each side of a median horizontal band; pectoral and ventral clear; anal with a large diffuse blotch of dark greenish.

134. Therapon jarbua (Forskål).

A specimen each, 4 inches long, from Manila and Calayan, and two young examples, under 1 inch, from Ticao Island. Color in life of the Manila specimen silvery, washed with bluish steel; each side with three curved longitudinal bands, the first beginning at front of spinous dorsal and ending under soft dorsal, second beginning midway between occiput and first dorsal spine, curving downward to below lateral line, and then upward to its termination behind soft dorsal; third beginning on occiput, whence it passes downward along posterior margin of opercle, then backward along side, under the lateral line anteriorly, to the base of the caudal fin; three dusky bands on caudal; anal and ventral clear white, the former reddish yellow externally, the latter reddish yellow mesially; a large dusky blotch on first dorsal; two smaller dusky blotches on margin of second dorsal; an obsolete line of golden yellow above ventral and anal.

HELOTES Cuvier.

135. Helotes sexlineatus (Quoy & Gaimard).

One example, 4 inches long, from Manila.

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[a] Originally misprinted *Terapon*, "an error of transcription."

SCOLOPSIS Cuvier.

136. Scolopsis cancellata Cuvier & Valenciennes.

One specimen, 3.50 inches long, from Cuyo. In life the upper half brown, with three pale yellow stripes; lower half silvery white; vertical fins washed with pink; paired fins white with a black spot in each axil.

POMADASIS Lacépède.

137. Pomadasis argyreus (Cuvier and Valenciennes).

Eight specimens, 2.50 to 4 inches long, from Manila. Color in life of largest examples silvery white, washed ventrally with elusive yellow; fins more strongly yellow; a dusky spot on posterior part of opercle; eye large, 3.2 in head; second anal spine long and slender.

These specimens are certainly not different from those described and figured by Bleeker as *Pristipoma argyreum*, and figured by Day as *P. guoraca*. The *P. guoraca* and *argyreum* of Bleeker appear to be different species, the first having a much smaller eye and shorter and heavier second anal spine, and being probably identical with the *Guoraka* of Russell.

138. Pomadasis argenteus (Lacépède).

Two specimens from Manila, 3 to 4 inches. Color in life silvery, with dusky spots on each scale of upper parts; pectoral pale yellow; other fins a little dusky; spines of dorsal silvery.

139. Pomadasis maculatus (Bloch).

A single example, 3 inches long, from Manila. General color in life dusky silvery; five dusky vertical blotches on side, three below dorsal crossing lateral line, and two on caudal peduncle, the first just behind soft dorsal; dorsal and caudal fins dusky; pectoral clear; ventral light yellow; anal dusky yellow.

PENTAPUS Cuvier & Valenciennes.

140. Pentapus caninus (Cuvier & Valenciennes). (*Pentapus bifasciatus* Bleeker.)

Two specimens, 2.50 inches long, from Cuyo. Color in life brown, the side stripes and belly white.

PLECTORHYNCHUS Lacépède.

141. Plectorhynchus orientalis (Bloch).

One specimen from Calayan, 4 inches long. In life white, with large irregular dark seal brown bands and blotches; one irregular wide band from eye to end of caudal on each side, connecting across occiput; a transverse interorbital band; another paler narrow band from base of pectoral to and on anal; dusky spot on snout and another on each side below eye, bordered with yellow; caudal crossed diagonally above and below by seal brown bands; spinous dorsal crossed by two brown bands; soft dorsal with one band; both dorsals white and yellowish on margins; ventral white; red spots in axils of ventral and pectoral.

142. Plectorhynchus lineatus (Linnæus).

Three specimens from Aparri, 2.50 inches long, agreeing in all respects with the original figure and description of *Diagramma albovittatum* of Rüppell. Rüppell's types were 5 inches long.

Family SPARIDÆ.

LETHRINUS Cuvier.

143. Lethrinus mœnsii Bleeker.

One specimen, 7.50 inches long, from Calayan. Depth 3.2; head 2.75; snout 2 in head; teeth all conical and pointed; each side with 6 indistinct dusky cross bands; a dark spot at base of each dorsal spine and ray. In life brownish; dorsal and caudal marked with red; a red spot on opercle.

This species appears to be close to *Lethrinus variegatus* Ehrenberg (*L. latifrons* Rüppell), from which it is distinguished apparently by its more slender form and by certain differences in coloration.

144. Lethrinus mahsenoides Ehrenberg.

A specimen 4 inches long from Cuyo agrees with others called *Lethrinus mahsenoides* by Jordan & Seale. Depth 2.50 to base of caudal; posterior teeth molar; coloration in spirits uniform pale olive, each scale of sides and back with a faint dark spot at base; base of dorsal spines dusky. The third, fourth, and fifth dorsal spines are the longest. The specimen is evidently close to *Lethrinus hæmatopterus* of Temminck & Schlegel, and may be that species. We have no notes on the life colors.

Family KYPHOSIDÆ.

KYPHOSUS Lacépède.

145. Kyphosus cinerascens (Forskål). (*Pimelepterus tahmel* of Günther.)

One example, 6 inches long, from Calayan. This species is known by its high soft dorsal, with 12 rays, and the numerous brown longitudinal stripes on the body. As pointed out by Doctor Day, it seems that the name *cinerascens* should replace that of *tahmel*, used by Doctor Günther. Forskål's *Sciæna cinerascens, tahmel*, seems to be a parallel of his *Sciæna ? armata, galem fish.* In both these cases the second word is evidently the intended specific name and should so stand.

Family GERRIDÆ.

XYSTÆMA Jordan & Evermann.

146. Xystæma punctatum (Cuvier & Valenciennes).

One example, 3.50 inches long, from Calayan; one from Aparri, 3 inches; and one from Iloilo, 2.25 inches.

147. Xystæma kapas (Bleeker).

One specimen, 3 inches long, from Cuyo. Depth 2.8; head 3; second anal spine stronger but shorter than third; scales 40; color plain silvery, spinous dorsal tipped with dusky.

This specimen does not appear to differ, except in the smaller number of scales, from the specimens from Apia, Samoa, recorded as *Xystæma argyreum* by Jordan & Seale.

Family MULLIDÆ.

UPENEUS Bleeker.

148. Upeneus chryseredros (Lacépède). *Timbungan; Ubacan.*

Two specimens, 4 and 6.50 inches long, from Cagayancillo. In life (large specimen) white below; a bluish wash above; a rosy wash on opercle, preopercle, and tail; a yellow saddle behind second dorsal; several lines of dark yellow and lavender from snout through eye, and a number of lines radiating from upper side of eye; rays of first dorsal lavender, membranes yellow; second dorsal irregularly striped with lemon yellow and lavender; anal like second dorsal; pectorals and ventrals clear. The smaller specimen was lemon all over in life, darker above and a little paler below, brighter on fins. Under the rules of the International Code of Zoological Nomenclature, the type of *Upeneus* is *Upeneus bifasciatus*, not *U. vittatus*. (See Jordan & Evermann, Fishes North and Middle America, I, p. 857.)

149. Upeneus barberinus (Lacépède). *Amacan.*

One specimen 5 inches long and one 2.50 inches, from Cuyo. General color in life silvery; dark brown next to dorsal, below which is a wide golden stripe from eye, fading out below posterior end of dorsal; below the golden stripe a short black stripe which is just below lateral line; lower half of head silvery, washed with crimson; a large black spot on caudal peduncle; lower part of sides and all fins faintly washed with crimson.

UPENEOIDES Bleeker.

150. Upeneoides sulphureus (Cuvier & Valenciennes).

Three specimens from Manila, 3 to 4.50 inches long. Color in life dusky blue above, a rosy wash on head; sides silvery, with two lines of chrome yellow, one from head, the other from pectoral to caudal; a band of pale sulphur yellow from base of ventral to end of anal and including these fins; several longitudinal lines of white and dark brown on dorsal; caudal dusky, edged with brown.

151. Upeneoides vittatus (Forskål).

Two specimens, 3.50 and 4.50 inches long, from Lubang, and one from Iloilo, 3 inches.

152. Upeneoides tragula (Richardson).

Three examples, 4.50, 2.50, and 3.75 inches long, from Cuyo.

153. Upeneoides luzonius (Jordan & Seale).

A specimen 4.50 inches long from Manila agrees with the cotypes of this species. We are not certain that it is different from *Upeneoides tragula*, from which it appears to differ in coloration though apparently in no other characters. Our specimen has no dark marking on either dorsal fin.

Family SCIÆNIDÆ.

PSEUDOSCIÆNA Bleeker.

154. Pseudosciæna anea (Bloch).

One example, 3.75 inches long, from Manila. Color in life silvery; first dorsal black; frontal region dusky; a dusky spot on opercle and another above it; pectoral, ventral, and anal pale yellowish.

UMBRINA Cuvier.

155. Umbrina dussumieri Cuvier & Valenciennes.

One specimen from Manila, 4 inches long. In life silvery, dusky above; first dorsal dusky, second lighter; a few specks of dusky in axil of pectoral; ventral and anal white; caudal pale yellowish, with dusky tip.

Family SILLAGINIDÆ.

SILLAGO Cuvier.

156. Sillago sihama (Forskål). *Asohos.*

Two examples, 5 inches long, from Manila, and two from Aparri, 3 and 4 inches.

Family PSEUDOCHROMIDÆ.

CICHLOPS Müller & Troschel.

157. Cichlops spiloptera Bleeker.

A specimen, 6 inches long, from Fuga Island, and one from Calayan, 4 inches. Color in life of the example from Calayan: Deep claret, a little lighter below lateral line; each scale with a small deep blue spot; head dark green, top very dark, lighter at jaws; several blue and red lines crossing face under eye; opercle heavily spotted with blue; pectoral and ventral pale claret; dorsal light claret, curiously marked with short dusky lines and spots, and with a subterminal margin of bright scarlet followed by a very narrow blue line; caudal the color of body, each membrane with a long, thin scarlet line; anal strongly banded with deep scarlet and blue.

In the blue spot on each scale our specimens resemble *Cichlops cyclophthalma* Müller & Troschel, but the depth is less and the length of the head less than is stated for that species, and the specimens have not the dorsal marked posteriorly as figured and described by Bleeker from his example of *C. cyclophthalmus*. Our specimens agree in proportions, fins, scales, and in all details of coloration except presence of spots on scales of sides, with Bleeker's figure and description of *Cichlops spiloptera*. The condition of one of our specimens indicates that the blue side spots fade easily, which probably accounts for their absence from Bleeker's figure.

158. Cichlops melanotænia Bleeker.

One example, 3 inches long, from Cuyo. In life dull reddish, each side with ten narrow black longitudinal lines; rows of dark red spots about eye; dorsal and ventral bright red; dorsal spotted; pectoral yellowish.

Family OPISTHOGNATHIDÆ.

GNATHYPOPS Gill.

159. Gnathypops dendritica Jordan & Richardson, new species. *Tabangca.*

Head 2.66 in length without caudal; depth 3.40; eye 3.20 in head; interorbital space 3.70 in eye; nose 2 in eye; maxillary 1.33 in head, extending for half its length behind eye; teeth in bands in both jaws, those in the outer row somewhat enlarged and slightly recurved; dorsal XI, 13; anal II, 13; pectorals 2 in head; ventrals 1.75; dorsal inserted over base of pectorals; anal inserted under eleventh ray of dorsal; scales 105; lateral line high, running along back half an eye length from base of dorsal, and terminating over middle of anal; anterior pores of lateral line branched; top and sides of head and predorsal region with numerous, variously connected, branching mucous channels, those immediately in front of the dorsal fin disposed in a tree-like pattern.

Color in spirits light grayish brown with darker brown spots and blotches, these connected in a coarse reticulated pattern on posterior part of trunk and caudal peduncle; scapular region, opercles, and cheeks sparsely sprinkled with coarse black specks; each upper jaw crossed by a broad band of dusky near tip, under which is a dark spot; spinous dorsal with a large squarish black blotch between third and fifth spines, and similar but smaller and fainter spots on the other membranes, near base of fin; outer edging of spinous dorsal white, above a submarginal zigzag streak of black; soft dorsal barred lengthwise with dusky just below middle, its outer margin dusky, the middle of the fin and its basal portion pale; anal marked like soft dorsal; caudal broadly tipped with blackish and barred crosswise with blackish near base, the middle of the fin pale; ventrals faintly dusky posteriorly; pectorals pale, with a faint diffused dusky spot at base.

FIG. 9.—Gnathypops dendritica, new species. Type.

One specimen, 5.25 inches long, the type, from Cuyo, no. 20313, Stanford University. On this specimen, Mr. McGregor has the following note concerning life colors: "General color brown, mottled with light yellow and dotted with black; head light yellow, sparsely spotted with black, but more thickly spotted on interorbital and postocular areas; pectorals rich yellow with an irregular dark spot at base; ventrals lighter yellow with black tip; dorsal mottled with brown, spines tipped with white, below which is a narrow black line; a quadrangular black spot between third and fifth spines; each membrane with a small black spot near its middle followed by a white spot; anal light yellowish, tipped broadly with black and with a dark brown bar across middle; caudal yellowish, irregularly barred near base and broadly tipped with black; a dark brown spot at base of caudal."

Family ANABANTIDÆ.

ANABAS Cuvier.

160. Anabas testudineus (Bloch, 1792). (=*Perca scandens* Daldorff, 1797.)

A single specimen from Sibuyan, 2.75 inches long.

Family POMACENTRIDÆ.

POMACENTRUS Lacépède.

161. Pomacentrus nigricans Lacépède. (*Pomacentrus scolopseus* Quoy & Gaimard.)

Three specimens from Calayan, 0.75 to 2.75 inches long, and one from Cagayancillo, 3 inches. General color in life of the specimens from Cagayancillo very dark, almost black; most of the scales on body marked with a dark violet spot; a band of violet from mouth under eye; fins black.

The present species has twelve dorsal spines and a black blotch on base of pectoral and on last rays of soft dorsal. The specimens we have called *Pomacentrus albofasciatus*, following Jordan & Seale, differ only in the presence of the pale crossbands on the posterior part of the body.

162. Pomacentrus albofasciatus Schlegel.

Two specimens from Calayan, 2.50 inches long, taken from coral-rock tide pools. Dorsal spines 12. Color in life dusky brown; an ill-defined black blotch on anterior part of dorsal; a dusky spot on posterior base of dorsal; a broad white band across body behind tip of pectoral; a dusky spot in axil of pectoral.

163. Pomacentrus pristiger Cuvier & Valenciennes. *Palata.*

A single specimen, 3 inches long, from Cuyo. Dorsal spines 13; a black spot at tip of opercle.

We follow Sauvage in identifying the present specimen with *Pomacentrus pristiger* (=*littoralis* of Bleeker, and Günther, part). This species is near *Pomacentrus tripunctatus* Cuvier & Valenciennes (=*trilineatus* of Sauvage), but is distinguished by having all the suborbital denticulations equal, and by the absence of a black spot on the top of the caudal peduncle.

The specimen from Cuyo had the following colors in life: Body dull dark green; fins dark brown; a line under eye and a spot in front of eye; some spots on top of head of a rich violet color; opercles faintly washed with violet.

164. Pomacentrus littoralis Kuhl & Van Hasselt.

Four specimens, 2 to 3 inches long, from Cavite, collected by Dr. G. A. Lung and recorded by Jordan & Seale under the name *Pomacentrus tripunctatus* Cuvier & Valenciennes, evidently belong to this species as redefined by Sauvage, from the types. The anterior suborbital denticulation is enlarged and followed by a notch, and there is a round black spot on the tip of the opercle, as in *Pomacentrus tripunctatus*, but the top of the caudal peduncle is without blotch; dorsal spines 13.

165. Pomacentrus emarginatus Cuvier & Valenciennes.

Two young specimens from Ticao and a well-colored adult, 2.50 inches long, from Cuyo, should probably be referred to this species; dorsal spines 13.

We can find no differences between the species called *emarginatus* and *chrysurus* by Cuvier & Valenciennes. Sauvage states that *Pomacentrus chrysurus* has only two rows of scales on the preopercle. The scales are in three rows in our largest specimen, which has the caudal deep yellow, in strong contrast with the contiguous color on the caudal peduncle. All the other fins are without spots or ocelli. The two young specimens both have an ocellus at the back of the soft dorsal, like *Pomacentrus delurus* Jordan & Seale, but lack the fully developed third row of scales on the preopercle present in the type of *Pomacentrus delurus* as figured by Jordan & Seale. A cotype of *P. delurus*, however, agrees with the present specimens in having only two developed rows. It is probable that *Pomacentrus delurus* is the young of the forms called *Pomacentrus emarginatus* and *chrysurus* by Cuvier & Valenciennes, and it is not impossible that these in turn, when a full series is examined, will prove to be not different from *Pomacentrus littoralis.*

166. Pomacentrus fasciatus Cuvier & Valenciennes.

Two specimens from Ticao Island, 0.75 and 1.25 inches long. Color in spirits brown, with 4 light cross bands, narrower than the dark interspaces; one of these crossing opercle, one crossing the body in front of the fourth dorsal spine, one originating at junction of spinous and soft dorsal, and the last one crossing the root of the caudal peduncle; the two middle bands are continued upward on the dorsal fin; on the top of the opercle there is a small black spot, and behind this several dark specks, forming two indistinct series, ceasing over tip of pectoral; the suborbital is smooth and the preopercle only weakly denticulated, or crenulate.

ABUDEFDUF Forskål.

167. Abudefduf saxatilis (Linnæus).

One specimen 2 inches long from Manila, and one from Calayan, 1.50 inches, in tide pools. Color in life of Calayan specimen: Pale bluish white; body and dorsal crossed by four vertical bands of dark-blue (washed out on belly), between which are three golden yellow areas; head black; belly white.

168. Abudefduf dicki (Liénard).

A single example from Cagayancillo, 3 inches long. Color in life brown; a black band at beginning of soft dorsal, the color behind the band light fawn; pectoral rich yellow.

169. Abudefduf zonatus (Cuvier & Valenciennes). (*Glyphidodon brownriggii* Günther, not of Bennett.)

One specimen from Cagayancillo, 2 inches long.

170. Abudefduf unimaculatus (Cuvier & Valenciennes). (*Glyphidodon dispar* Günther.)

Eight specimens from Calayan, 1.50 to 2.50 inches long, and one from Cagayancillo, 2.50 inches. These specimens have the dorsal XIII, 12 or 13, and the anal II, 11 or 12, and each scale of the body with a more or less distinct vertical light streak, these forming longitudinal rows on the sides. Four of the Calayan specimens, probably males, have all the fins except pectorals dusky, the dorsal with a distinct black spot at the base of the last four rays. The others, probably females, have the body and fins paler,

and the dorsal without distinct dark blotch. The life colors of one of the specimens from Calayan (probably female) are described by McGregor as "stone gray; belly white; a narrow red line across base of pectoral."

171. Abudefduf amabilis (De Vis). (*Glyphidodon brownriggii* var. *xanthozona*, Günther, Südsee; not *G. xanthozona* of Bleeker.)

Three specimens, 0.75 to 2.50 inches long, from Calayan.

172. Abudefduf glaucus (Cuvier & Valenciennes). (*Glyphidodon modestus* Schlegel.)

Three specimens, 2 and 2.50 and 2 inches, from Cagayancillo and Ticao. Life color of Cagayancillo specimen bluish gray above; white below.

173. Abudefduf antjerius (Kuhl & Van Hasselt). (Not *Glyphidontops antjerius* Bleeker = *Chætodon brownriggii* Bennett.)

Two specimens, 0.50 inches long, from Ticao Island, and two, 1 inch, from Calayan. These specimens have a black blotch partly on back and partly on base of latter part of spinous dorsal, and a small black spot on posterior base of soft dorsal. A narrow sky-blue band, not wider than pupil, passes backward from in front of and above eye on each side to a point on top of the back directly under the fifth or sixth dorsal spine. Comparison with Samoan specimens indicates that the sky-blue stripe fades or becomes narrower with age. In no case does it appear to occupy the whole space between the base of the dorsal and the lateral line, nor does it extend backward beyond the fifth or sixth ray of the spinous dorsal.

174. Abudefduf brownriggi (Bennett). (Not *Glyphidodon brownriggii* of Günther, which is *A. zonatus*.)

A single example, 0.66 inch long, from Ticao Island, may be referred to this species. The specimen has a black blotch at the back of both dorsals, and the space between the lateral line and the basal edge of the dorsal fin is a bright sky blue, in a band about equal in width to orbit, and extending as far back as the base of the caudal peduncle; body below lateral line pale brownish olive in spirits. This species, or form, does not differ from *Abudefduf leucopomus* except in the absence of the black blotch on the top of the base of the caudal fin. From *Abudefduf antjerius* it seems to differ mainly in the greater width and length of the sky-blue band, and in the sharp demarcation of the upper color from that below the lateral line.

175. Abudefduf sapphirus Jordan & Richardson, new species.

Head 3.37 in length to base of caudal; depth 2.50; dorsal XIII, II; anal II, 11 or 12; scales 27; eye 3 in head; nose 4.50; interorbital space 3.80; maxillary 3 in head, equal to eye, its tip under anterior

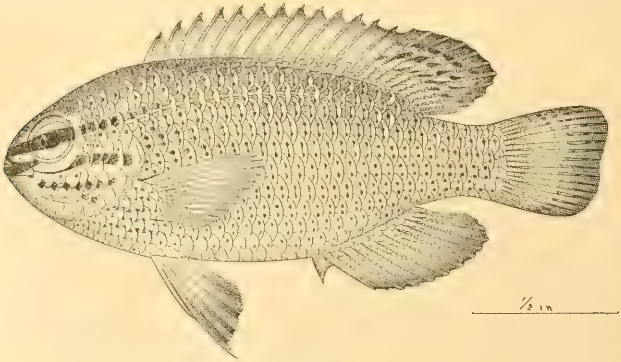

FIG. 10.—Abudefduf sapphirus, new species. Type.

border of orbit; teeth compressed, in a single row in each jaw, not notched; preopercle not denticulate; pectoral 1.27 in head; ventral 1.16; caudal 1.20; subtruncate, the upper rays a little the longest; depth of caudal peduncle 3 in head.

Color in spirits of head, body, and fins, except pectorals, bright sky blue; each scale of sides with one or two very small round black specks; a black band as wide as pupil from the top of the gill-opening, through eye, to end of snout; two narrower, wavy or broken black lines on cheek below eye, and three of these crossing opercle; top of head between eyes with several small black specks; spinous dorsal plain sky blue; soft dorsal, caudal, and anal sky blue, specked with dusky outwardly, and tipped with black; rays of ventrals sky blue, dusky toward tips; pectorals sky blue at base, otherwise colorless (transparent).

Known from 6 specimens from Ticao Island, 1.25 to 1.75 inches long. The sky-blue color of body and fins, and the black-edged soft dorsal, caudal, and anal appear to distinguish this species. The type is no. 20207, Stanford University; cotypes are no. 61682, U. S. National Museum.

176. Dascyllus melanurus Bleeker. *Calitbobo.*

A single specimen, 2.33 inches long, from Cagayancillo.

General color in life pale green, belly white; body decorated with four wide black bars which extend on fins above and below; one across frontal region, eye, and chin; one from anterior third of dorsal through base of pectoral and on ventrals, which fins are black; one from posterior third of dorsal to and including anal; and the last on posterior two-thirds of caudal.

Family LABRIDÆ.

CHOIRODON Rüppell.

177. Choirodon anchorago (Bloch). *Banquilan.*

A single specimen from Cuyo, 4 inches long. Life color, above gray; lower half and belly white; head greenish; opercle and preopercle spotted with brick red; line above eye and two irregular lines from eye to mouth brick red; spots of the same color from head backward to end of dorsal, above lateral line; pectoral rich yellow, the base blue crossed by a line of dark brick red; ventral white, membrane between first and second rays pale red; dorsal dull greenish, barred with two lines of brick red, one subterminal and one near the base, the latter ending on first ray; anal light lemon yellow and white, tipped with a marginal line of bright orange; caudal dirty reddish brown, base pale blue; iris bronze, surrounded by blue.

178. Choirodon oligacanthus (Bleeker).

One specimen from Iloilo, 3.50 inches long.

AMPHECES Jordan & Snyder.

179. Ampheces pterophthalmus (Bleeker).

One specimen from Cuyo, 6 inches long.

General color in life, dark purple; a large ocellate black spot on posterior part of dorsal and anal fins, surrounded with yellow; a bluish interocular stripe; pectoral yellow.

STETHOJULIS Günther.

180. Stethojulis strigiventer (Bennett).

Four specimens from Cuyo, 2.50 to 4 inches long.

Life colors of Cuyo specimen: A line of light blue from above nose through top of eye along middle of body to and on to base of caudal; side above this line brown, below it white, washed with yellow; another blue line from snout backward below eye, ending just below base of pectoral; a third blue line from gill-opening passing below pectoral and ending below middle of dorsal; space between the last two lines salmon pink in front of pectoral; opercle washed with pink; a light blue line on each side of dorsal, uniting posteriorly; a bit of blue on side of chin; fins all clear and colorless.

181. Stethojulis phekadopleura Bleeker.

Four specimens, 1.50 to 2.75 inches long, from Cuyo and Calayan.

Color in life of Cuyo specimen (2.75 inches in length): Above black, finely speckled on body with pale blue; lower parts bluish; two[a] parallel rows of large spots extending from pectoral to below end of dorsal; dorsal and caudal slightly red; dorsal finely speckled with pale blue.

[a] A third and fainter row shows in preserved specimens.

182. **Stethojulis bandanensis** (Bleeker).

One example 4 inches long from Cuyo, and one, 3 inches, from Cagayancillo.

Life color of Cuyo specimen: Above dark greenish, finely and regularly speckled with pale blue; a salmon-colored spot over pectoral and a small blue crescent in axil; a short yellow band from angle of mouth to below eye; a fine blue line under eye; a small ocellated spot on lateral line at end of caudal peduncle; dorsal finely spotted with blue; lower parts very pale blue.

183. **Stethojulis zatima** Jordan & Seale. *Lugday.*

One example, 2.50 inches long, from Cuyo, and 3 from Calayan, less than 1 inch in length, all obtained in tide pools.

Mr. McGregor has the following note on the life colors of the Cuyo specimen: "Dark grass green, tending to pale blue on belly; sides below lateral line crossed by about five light lines; a narrow silvery line from mouth across head, becoming brilliant blue on opercle; a narrow dark bar at base of tail and a small black dot on tail above lateral line; caudal and ventral pale blue, washed basally with golden; preopercle silvery."

PLATYGLOSSUS (Klein) Bleeker.

184. **Platyglossus notopsis** (Kuhl & Van Hasselt).

Four specimens, 1.50 to 1.75 inches long, from Calayan. Color in life, black, with six or eight pale yellow lines from snout and lower jaw to tail, radiating over side of body; in some specimens these lines are obsolete; caudal white.

HALICHŒRES Rüppell.

185. **Halichœres centiquadrus** (Bleeker). *Payuc.*

One specimen from Cagayancillo, 5 inches in length.

Life colors: Body white, each scale with a black mark, these larger on upper than on lower part of sides; belly pure white; a large black spot below and on anterior portion of dorsal; in front of dorsal the black spots are salmon instead of black; head green; lips light yellow; several curious dark salmon marks on head, one from maxillary through eye, two on opercle, and one from chin to margin of preopercle; a spot of salmon on part of lower preopercle; several pink spots on scales below pectoral; three bright lemon-yellow spots next to dorsal, one of them in front of the black spot, another some distance behind it, and the third one behind dorsal; dorsal reddish with numerous large chrome-yellow spots; caudal brilliant chrome yellow; pectoral and ventral clear; a bright vermilion spot on base of pectoral behind; a dark spot on base above; anal with stripes of pale pink and yellow.

186. **Halichœres gymnocephalus** (Bloch & Schneider).

Two specimens, 3 and 4 inches long, from Cuyo.

General color in life, including dorsal, caudal, and anal, light green; a large black blotch on side behind pectoral; belly white; a pink band from snout to eye; a dark green spot on preopercle, bordered with blue; base of pectoral yellow with a dark band; a light green band under base of pectoral; iris light green.

187. **Halichœres trimaculatus** (Quoy & Gaimard).

One example, 3 inches long, from Cagayancillo.

General color in life, pale yellowish above and white below; each scale marked with a vertical bar of pinkish, on some scales mixed with brown; on lower part of body the bars are faint or wanting; head beautifully marked with bands of pink and pea green, two of each color from eye to snout; behind eye and on upper opercle several pink spots; preopercle light yellow; top of head from interorbital to dorsal dotted with pink; a pink band beneath pectoral; dorsal transparent, with three longitudinal bands of pink and one of green; anal transparent; a band of pink near base; pectoral transparent, a small dark spot in its axil, bordered with blue; ventral pale pea green; caudal transparent, tipped with a reddish wash.

188. **Halichœres miniatus** (Kuhl & Van Hasselt).

One specimen from Calayan, 2.50 inches long.

189. Halichœres pœcilus (Lay & Bennett).

Two examples from Calayan, 3 and 3.50 inches long, from a tide pool.

Color in life: A pea-green band on cheek; a large brown spot bordered with blue on opercle; dorsal and anal greatly variegated, mottled with green and light claret; a large black spot between second and third dorsal rays; ventral pale green, edged with claret.

190. Halichœres nebulosus (Cuvier & Valenciennes).

Three specimens from Cuyo, 2.75 to 3.25 inches long.

In life brightly colored and variegated; on head various irregular markings of light brick red and bright green, bordered narrowly with bright blue; body purplish, marked with green spots and blotches; dorsal reddish, marked with ocellated green spots; anal similar to dorsal, with a median green band bordered with bright blue; caudal pale yellowish, with spots of dark red; pectoral colorless; ventral pale green, the long rays pale reddish.

191. Halichœres opercularis (Günther).

Seven specimens from Calayan, 2 to 3 inches long, and one without locality label. One of the Calayan specimens has a small black spot on the back part of the soft dorsal, in addition to the normal median and anterior spot. It does not otherwise appear to differ from the other examples.

CHEILIO Lacépède.

192. Cheilio inermis (Forskål).

Three specimens from Cuyo, 6 to 7.50 inches long.

General color in life, dark green above and light brown below median line; each scale below with a pale blue spot; a median line of black spots; dorsal and caudal pale green; pectoral, ventral, and anal clear; a few dark reddish marks on chin.

THALASSOMA Swainson.

193. Thalassoma dorsale (Quoy & Gaimard).

One specimen from Cagayancillo, 3 inches long.

194. Thalassoma guntheri (Bleeker).

One specimen from Calayan Island, 3 inches long.

Color in life: Head and body with broad longitudinal lines of rank emerald green and purple; dorsal with lines of same green and more delicate shades; pectoral and ventral washed with pale green; belly light blue; caudal washed with pale red, green, and yellow, tending to form bars; two outer rays of caudal deep purple.

195. Thalassoma umbrostigma (Rüppell).

A single specimen, 2 inches long, from Calayan.

CHEILINUS Lacépède.

196. Cheilinus digrammus (Lacépède).

One specimen from Romblon, 5 inches long.

197. Cheilinus oxycephalus Bleeker.

Depth 2.50 in length to base of caudal; head 2.80; nose 3.66; interorbital space $1\frac{1}{3}$ times eye; eye 4.4 in head; maxillary 3.33; canines small; dorsal x, 9; anal III, 8; pectoral 2 in head; ventral 1.70; scales 20; lateral line interrupted; head fully scaled.

One example from Cuyo, 3.50 inches long.

Color in spirits brownish, vaguely mottled and clouded with darker both on body and on vertical fins; four dusky spots, each about size of pupil, forming a row along middle of each side, the first spot above the tip of the reflexed pectoral, the next one above the middle of the anal, the third above the back of the anal, and the last at base of caudal fin; soft dorsal with an indistinct dusky blotch at the base of its last rays.

General color in life, green, sparsely spotted with brick red, most thickly on head; edges of dorsal, caudal, and anal marked with red.

NOVACULICHTHYS Bleeker.

198. Novaculichthys tæniurus (Lacépède). *Calili.*

A single example, 5.50 inches long, from Cagayancillo. The specimen in spirits shows two short dark lines radiating backward from posterior margin of orbit, and two longer ones extending downward and backward across cheek and opercle.

In life dusky brown in general color; a whitish spot on each scale; dorsal, anal, and caudal similar to body, but barred instead of spotted; pectorals light yellow, dusky at base; ventrals dark reddish brown with white tips; a broad white bar at base of caudal; head dirty green; lips yellowish.

Family SCARICHTHYIDÆ.

SCARICHTHYS Bleeker.

199. **Scarichthys auritus** (Kuhl & Van Hasselt). *Busalog; Layag layag.*

One example from Cagayancillo, 3.50 inches long. Life colors: Body dirty green, with irregular spots of brown and light blue; head dirty green, with numerous spots of purplish blue; fins light reddish brown with dark mottling of the same color.

CALOTOMUS Gilbert.

200. **Calotomus moluccensis** (Bleeker).

One specimen from Cuyo, 5 inches long.

General color in life, dark green, sparsely spotted with brick red. This species may be recognized by the presence of a distinct black blotch between the second and third dorsal spines. We may here note that the description and figure of *Calotomus carolinus*, from Rarotonga, were by some accident included in the recent paper on the Fishes of Samoa, by Jordan & Seale, under the name of *Scarichthys cæruleopunctatus* (Rüppell).

CALLYODON Gronow.

201. **Callyodon capistratoides** (Bleeker).

General color in life, dull brown with a purplish wash; a blue band over mouth to below posterior margin of eye; another below mouth, below that a pink line, then a blue line, then pink again, and below that two greenish spots; belly with a median blue line from isthmus to vent, continued on edge of anal fin; gill covers dull purple; a blue wash on pectoral; ventral blue, three rays pink; base and edge of anal blue, middle pink; dorsal similar to anal; caudal with upper and lower edges broadly blue, tip pink, a subterminal blue band, base purple.

A single example, the type, from Cagayancillo, 6 inches in length.

Family TOXOTIDÆ.

TOXOTES Cuvier.

202. **Toxotes jaculatrix** (Pallas).

Three specimens, 3.50 to 5 inches long, from Mindoro Island.

Family EPHIPPIDÆ.

EPHIPPUS Cuvier.

203. **Ephippus argus** (Gmelin). *Citang.*

One example, 6 inches long, from Manila, and one from Iloilo, 2 inches.

Family DREPANIDÆ.

DREPANE Cuvier & Valenciennes.

204. **Drepane punctata** (Gmelin).

Two specimens from Manila and one from Lubang, 3 to 4 inches. Color in life silvery; five vertical rows of long dusky spots from dorsal to near ventral margin; one spot on caudal peduncle; fins pale dusky greenish, all of them except pectoral broadly margined with dusky.

Family PLATACIDÆ.

PLATAX Cuvier.

205. **Platax orbicularis** (Forskål).

Three specimens from Ticao Island and one from Cagayancillo, 1.50 inches long.

Family SCORPIDÆ.

MONODACTYLUS Lacépède.

206. Monodactylus argenteus (Linnæus).

One specimen from Aparri, one from Iloilo, and two from Calayan, 2 to 3 inches.

Family CHÆTODONTIDÆ.

GONOCHÆTODON Bleeker.

207. Gonochætodon triangulum Cuvier & Valenciennes. *Culbangbang.*

One example from Cagayancillo, 3.50 inches long.

CHÆTODON (Artedi) Linnæus.

208. Chætodon ephippium Cuvier & Valenciennes.

One specimen from Cagayancillo, 5 inches long.

209. Chætodon setifer Forskål. *Culbangbang.*

Two specimens, 4 and 5 inches, from Cagayancillo.

210. Chætodon trifasciatus Park.

Two specimens from Cagayancillo, 3.50 inches. Color in life chrome yellow, most intense about base of pectoral; each side crossed by 13 deep violet longitudinal stripes, which are strongest above and fade out below pectoral; about six narrow longitudinal lines of the same color on dorsal; head mostly dark brown; a vertical dark brown band through eye, bordered on each side with light lemon yellow; above the eye the yellow lines are narrow, below eye they are nearly as wide as the brown band, a narrow brown line across head behind eye; belly, including ventral, rich lemon yellow; anal marked with the following colors, beginning on the base: (1) blue gray; (2) lemon yellow, extending forward to belly; (3) black; (4) darker lemon, which joins the upper yellow line around posterior end of black line; (5) broad band of rich red brown; (6) narrow lines of black and lemon yellow; (7) in front of black band and extending a little in front of anus, a dark salmon area; dorsal spines white; pectoral clear; a dusky spot on isthmus; caudal white, marked at its middle by a wide vertical black band, broadly margined with lemon yellow; dorsal on its posterior part marked with oblique lines and bands of black, brown, and lemon yellow.

211. Chætodon kleini Bloch.

One specimen, 3 inches long, from Cagayancillo.

212. Chætodon citrinellus (Broussonet).

One specimen, 2.75 inches long, from Cagayancillo. Color in life white with greenish wash, each scale with a violet spot; below line of pectoral the body white and scale spots pale yellow on caudal peduncle, base of caudal, and posterior margins of dorsal and anal; a black spot on snout; a dark brown band from predorsal region through eye to lower margin of gill cover, the band above the eye bordered on each side with pale green; membranes of spinous dorsal light blue at base, light yellow above; anal with terminal black band and subterminal light yellow band, these divided by a narrow pale blue line; caudal light golden yellow; ventral pale pea green, except the two shortest rays; pectorals clear.

HOLACANTHUS Lacépède.

213. Holacanthus bicolor Bloch. *Calit bobo.*

One example from Cagayancillo, 4 inches. Life colors: Anterior part of body, including first five dorsal spines and pectoral and ventral, rich orange chrome, bordered posteriorly with lemon yellow; caudal and tips of long dorsal rays rich chrome; caudal at base lemon yellow; posterior part of body, including most of dorsal and all of anal, solid black; a wide black band over frontal from eye to eye; head washed with dusky green; an orange submalar stripe; a spot of orange back of eye and a line of orange on margin of opercle; two indistinct orange lines at base of pectoral.

Family ZANCLIDÆ.

ZANCLUS (Commerson) Lacépède. *Calibagio.*

214. Zanclus cornutus (Linnæus).

One specimen from Cagayancillo and one from Fuga Island, 2.50 and 3 inches.

While the original descriptions of both *Chætodon cornutus* and *C. canescens* are unsatisfactory, the two species are figured both by Klein and by Bonnaterre in such a manner as to leave little doubt of their specific distinctness. Doctor Bleeker had specimens of the short-nosed form called by himself and by Bonnaterre *canescens*, and differing further from the common "Moorish Idol" in the absence of the triangular black marking on the side of the nose. The short-nosed form recently described from Hawaii by Bryan, and named by him *Zanclus ruthiæ*, is almost certainly not different from the *Zanclus canescens* of Bleeker and the *Chætodon canescens* of Bonnaterre and Linnæus.

Family HEPATIDÆ.[a]

HEPATUS Gronow.

215. **Hepatus olivaceus** (Bloch & Schneider). *Indangan.*

Of this species we have one well-preserved example from Cagayancillo, 3.50 inches long, plainly showing the pale bar above the pectoral, the length of the bar being about two-thirds that of the fin. The caudal lobes are very little prolonged, the specimen agreeing in that respect with examples (3 to 6 inches long) from Samoa. The figure of *Teuthis olivaceus* published by Jordan & Evermann was taken from a Formosan specimen 13 inches long, and has the caudal lobes greatly prolonged and the humeral bar reaching tip of pectoral. It is probably not, however, different. We note, in this connection, the occurrence in specimens of *Hepatus nigricans* from Pago Pago, Samoa, taken at the same time and place, about the same amount of difference in the prolongation of the caudal lobes between young and older specimens.

Life colors of the specimen from Cagayancillo: General color dark brown; humeral bar a narrow basal portion of dorsal mottled with gray; short rays of caudal tipped with white, the pale portion forming a conspicuous white crescent.

Two smaller specimens from Cagayancillo, 2.75 inches long, appear to be this species, but do not show the humeral bar. Their life color is described by Mr. McGregor as "bright yellow, speckled with brown; top of head and edges of dorsal, anal, and ventral darker." This description of the life colors corresponds well with that of Samoan specimens, except for the absence of mention of the humeral bar. It is not impossible that this may be indistinct in young individuals, or that these two examples were faded at the time of writing.

216. **Hepatus elongatus** (Cuvier & Valenciennes).

Two examples, 2.50 and 2.75 inches long, from Cagayancillo.

217. **Hepatus lineatus** (Gmelin). *Saguing saguing.*

A young specimen from Cagayancillo, 2.50 inches long. In life striped from mouth backward over whole body with colors in this order: Blue, black, yellow, black, blue; caudal peduncle vertically marked by two blue, one yellow, and four black lines; caudal with a blue crescent; dorsal yellow, with two blue lines, posteriorly dusky; pectoral clear; ventral orange black outwardly, edged with blue; anal yellow, with a greenish black line at base and with a blue edge; belly pale dirty blue.

218. **Hepatus matoides** (Cuvier & Valenciennes).

A specimen, 3.75 inches long, from Calayan, and two smaller ones, 1.50 to 2.25 inches long, from Aparri.

219. **Hepatus triostegus** (Linnæus). *Culaban.*

A specimen, 4 inches long, from Cagayancillo, and one of the same size from Fuga Island. A small example, 2.75 inches long, from Calayan Island.

ZEBRASOMA Swainson.

220. **Zebrasoma rhombeum** (Kittlitz). *Catol catol.*

One example, 3 inches long, from Cagayancillo. Life colors: Dark seal brown, darker posteriorly; dorsal, caudal, and anal black; sides of face and body finely dotted with blue, the dots joined in short lines on side of body.

[a] Under the rules of the International Code of Zoological Nomenclature the name *Monoceros*, Bloch & Schneider, must be used for *Chætodon unicornis* in place of *Acanthurus* or *Naso*. *Teuthis* was, however, first restricted by Cuvier as a synonym of *Acanthurus*=*Hepatus* Gronow.

Family SIGANIDÆ.

SIGANUS Forskål.

221. Siganus marmoratus (Quoy & Gaimard).

A single specimen, 6.50 inches long, from Calayan, agrees with specimens taken by Jordan & Kellogg in Samoa, except that the soft dorsal, anal, and caudal are not barred. The depth is 2.60 in the length to base of caudal, as in Samoan examples. In the absence of dorsal, caudal, and anal bars, the specimen agrees with Günther's figure of *Teuthis striolata*, which, however, is represented as a slenderer fish, having the depth nearly 3. We do not think it likely that the two forms are different.

Life colors of the specimen from Calayan: Upper half dusky green; lower half whitish; base of pectoral with a bright chrome-yellow bar above and below; sides with many yellow and dusky spots, each surrounded by pale blue; tail mottled with orange and dusky; anal red at base, followed by an orange band; dorsals dusky with a light yellow band near margin.

222. Siganus lineatus (Cuvier & Valenciennes). *Barangen.*

A specimen, 4 inches long, from Cuyo, and one from Aparri, 3 inches. Color of Cuyo specimen in life: Body white, slightly bluish above lateral line, covered with large spots of dull-brownish yellow; at back of dorsal a large golden yellow spot; top of head dark greenish; a light blue line behind eye which passes downward and forward under eye and then curves forward again, inclosing a golden yellow space; space outside blue line is also golden; a golden spot at beginning of anal.

223. Siganus javus (Linnæus).

One example, 4 inches long, from Manila, and one 3 inches from Iloilo. Life colors of the specimen from Manila: Dusky green, with numerous large spots of pale blue and of white; lower half of sides with indistinct lines of dusky and pale blue; pure white below pectorals and in front of ventrals; pectorals clear, other fins dusky; a wash of lemon yellow on face and in front of and along base of anal.

224. Siganus virgatus (Cuvier & Valenciennes). *Mandalada.*

One young specimen, 3 inches long, from Cuyo. In life this specimen had a wide band of dark reddish brown extending diagonally forward from in front of dorsal through eye to angle of mouth; a similar band of pale yellow behind this, followed by another reddish brown band, beginning between the fifth and seventh dorsal spines and tapering out over the base of pectoral; the last two bands are bordered with light blue; upper posterior half of body light yellow with a very large light reddish blotch in middle of side; dorsal brown, soft dorsal yellow; caudal yellow, pectoral, ventral, and anal pale; lower third of body silvery; three or four longitudinal blue lines between this and the large reddish blotch; several irregular diagonal blue lines on side of body in addition to those bordering the reddish brown bands; a line from eye to angle of mouth and another on preopercle; a number of blue spots along sides above lateral line; frontal region barred by about ten blue lines; interorbital and nasal region light yellow; chin dark.

225. Siganus corallinus (Cuvier & Valenciennes).

A specimen 5 inches long from Cagayancillo. Color in life bright yellow, closely covered with spots of light blue; top of head, pectorals, dorsal, and caudal without spots; spots enlarged at base of anal.

Although the caudal is without spots, there is little doubt that our specimen is the present species. *Siganus corallinus* is very close to *Amphacanthus guttatus* Bloch & Schneider, and may not be different.

226. Siganus rostratus (Cuvier & Valenciennes).

One example, 5.50 inches long, from Fuga Island.

227. Siganus oramin (Bloch & Schneider).

One small specimen, 2 inches long, from Aparri.

Depth 2.4 (3 in total, including caudal); caudal moderately emarginate; a dark spot on shoulder; chin crossed by two obscure dusky bands; body with scattered dusky blotches.

We also have specimens of the same species from Cavite and southern Negros, previously recorded, grading in size up to 5 inches. In examples under 3.50 inches, the white spots seem to be absent, in their place the sides bearing a few scattered dusky spots. In all the tail is very little emarginate, the depth of the notch being little more than the width of the pupil. All have an evident dusky blotch on the shoulder, have the two chin bands, and have the depth 2.40 in length to base of caudal. One speci-

men 5 inches long from southern Negros has the body a little more slender (depth 2.60) and the caudal notch deeper, its depth being greater than eye. Otherwise this specimen is not different from the rest.

In using the name *Siganus oramin* for specimens the most of which have a slightly emarginate tail and a dark blotch on the shoulder, while the figure of Bloch & Schneider shows a fish with a deeply forked caudal and without humeral blotch, we are of opinion that the poorly characterized *Amphacanthus guttatus*, var. *oramin*, of Bloch & Schneider is not really different from the *Amphacanthus dorsalis* of Cuvier & Valenciennes. Doctor Günther states that *Teuthis dorsalis* is without the dusky humeral spot, but later says that in the closely related *Teuthis albopunctatus* the shoulder spot becomes indistinct in older specimens. Were it not for the fact that Doctor Günther found the depth of specimens of *Teuthis albopunctatus* to be 3.50 in the total, we should have no hesitation in regarding it as identical with the present species, from which it is unlikely that it is different. Some of Doctor Günther's specimens of *Teuthis albopunctatus* were from the Philippines.

Family TRIACANTHIDÆ.

TRIACANTHUS Cuvier.

228. Triacanthus blochi Bleeker.

Three specimens from Iloilo and four from Manila, 3 to 4 inches long. In life silvery white; face yellow; several large spots of yellow on side, one under each dorsal; dorsal spine black at tip; caudal peduncle dusky above, fins yellowish.

Family MONACANTHIDÆ.

CANTHERINES Swainson.

229. Cantherines sandwichiensis (Quoy & Gaimard).

Three specimens from Romblon, 3.50 to 4.50 inches long.

230. Monacanthus tomentosus (Linnæus). *Pagnesan.*

Four specimens from Cuyo, 2.50 to 3 inches long, and one from Lubang, 2 inches. Color in life pale dirty green, slightly mottled; two incomplete dark bars across tail.

Two specimens from Panay, recorded by Jordan & Seale as *Monacanthus nemurus*, belong to this species. It is well distinguished from *M. nemurus* by the oblique pale bar above the pectoral and by the stouter and more strongly serrate dorsal spine.

Family BALISTIDÆ.

BALISTES (Artedi) Linnæus.

231. Balistes flavimarginatus Rüppell.

One example from Cuyo, 3.50 inches long. Color in life pale dirty yellow, lightly spotted with black on each scale; above, from mouth to eye and from eye to pectoral and about dorsals, mottled black; pectoral yellowish; two bands of dull green over snout to corner of mouth.

232. Balistes chrysopterus Bloch & Schneider.

One specimen, 4.75 inches long, from East Cove, Fuga Island. In life dusky brown; on chin dark purple; tail lighter brown, bordered on three sides with milk white; a white ring around mouth and another below this on chin; a large yellowish brown area below dorsal.

BALISTAPUS Tilesius.

233. Balistapus aculeatus (Linnæus).

A fine example from Cuyo, 6.50 inches. Colors in life: A yellow band over snout extending backward to below pectoral, its posterior portion salmon; on the snout the band includes a sky blue band which extends to the corner of the mouth; interorbital with four blue and three dark green bands, three of these extending below eye and uniting at base of pectoral; a black mark at base of pectoral and over gill-opening; a brown saddle in front of dorsal, extending forward and downward and merging into a dark area behind the gill-opening; spinous portion of caudal peduncle black; four parallel diagonal white bands from anal upward and forward to middle of body; fins colorless; lower parts white.

234. Balistapus rectangulus (Bloch & Schneider).

One specimen, 6 inches long, from Calayan Island. Life colors: A bluish saddle over mouth; interorbital space crossed by three black bars; a broad black band from eye downward to pectoral, where it widens greatly and extends backward across body to base of anal; parallel to this two pale blue lines from eye to pectoral; a bright red bar on base of pectoral; upper portion of body dark golden brown, lower anterior portion white; two V-shaped markings of green extend backward from median line, the arms of the larger meeting dorsal and anal; arms of smaller meeting fellow on opposite side of body just behind dorsal and anal; caudal peduncle black; a vertical green line at base of caudal; caudal dark golden brown.

235. Balistapus undulatus (Bloch & Schneider).

Two examples, 5 and 5.50 inches long, from Cagayancillo.

236. Balistapus verrucosus (Linnæus).

One specimen, 3.50 inches long, from Cagayancillo. In life with the body dusky green above and white below; a large dark brown patch on side behind pectoral; four blue lines connecting eyes on interorbital; three blue lines from eye to pectoral, inclosing a dark green area; a light yellow line in front of first blue line; snout light blue just back of upper lip and on each side back of angle of mouth; a narrow scarlet line from lower edge of pectoral forward and over snout to other side, separating the blue of the snout from the dusky green color above; a bar of blue and scarlet on base of pectoral; soft dorsal and anal barred with light yellow; middle of caudal yellow, its edges light orange.

Family TETRAODONTIDÆ.

SPHEROIDES (Lacépède) Duméril.

237. Spheroides lunaris (Bloch).

Three specimens, 2.50 to 3.75 inches long, from Manila, and one from Iloilo, 3.50 inches. In life silvery along sides, the color of which is sharply marked off from the dusky upper parts; belly dead white; a wash of pale yellow from mouth to and including pectoral; dorsal dusky with white base; anal white; caudal dusky, darker on edge; lower third milk white. The smaller examples are without yellow on the sides.

TETRAODON Linnæus.

238. Tetraodon hispidus Linnæus.

One example 3.75 inches long and one 3 inches, from Cuyo.

239. Tetraodon reticularis Bloch & Schneider.

A single specimen, 2.50 inches long, from Lubong.

240. Tetraodon immaculatus Bloch & Schneider.

One specimen, 3 inches long, from Lubang; three from Iloilo, 1 to 2.50 inches; one from Cuyo, 2.75 inches; and one from Ticao Island, 1.25 inches. The five smaller specimens all have the back striped and bristles short. The specimen from Lubang is without stripes and has the entire body covered with bristles[a] of fully twice the length of the longest in the other specimens.

[a] An examination of a number of specimens of *Tetraodon nigropunctatus* from Apia, Samoa, five of which are from 5 to 6.50 inches in length, some with long bristles and some apparently almost bristleless, favors the supposition that these fishes have the power of extruding and withdrawing into the skin at will these defensive bristles. It is noteworthy that the bristles in this species are found long (i. e., fully extended) only in specimens which are dilated, the grade of extrusion seeming to be related to the amount of dilation. Specimens in which the belly is not dilated ordinarily have the skin nearly smooth, except for small areas on the back and lower portion of each side, where the knobbed tips of the bristles show. On dissection of these it is found, however, that the apparently naked skin contains multitudes of long bristles (fully as long as those of the so-called "bristly" form), each withdrawn into an intracutaneous sheath. If a thin sagittal strip of skin is cut from the belly of a preserved specimen of one of these "naked-skinned" forms, by taking hold of it at either end with the fingers and stretching it quickly and smartly, the retracted bristles may be made to protrude for a considerable distance, up to about half their length. This fact seems to go some way toward verifying our supposition, deduced from observation of the condition of several dilated and undilated preserved specimens, that the bristles are thrown out upon dilation and probably not normally at any other time. One of the specimens from Apia, 5 inches long, is especially interesting as showing in the same individual part of the bristles fully extruded and the rest retracted. The fully extruded bristles are on the left side of the forward portion of the belly. It is probable that at the time of capture the bristles of the whole body were erected and that in dying there was a partial retraction, leaving the specimen in its present condition. The two figures of the so-considered "bristly" and "smooth" form of this species, published by Jordan & Seale (Fishes Samoa, fig. 70 and pl. 35), apparently represent exactly the same form of fish in the different conditions of extrusion and retraction of the bristles.

CHELONODON Müller.

241. **Chelonodon patoca** Hamilton-Buchanan. *Batete.*

Five specimens from Manila, 3 to 6 inches long.

Family GOBIIDÆ.

ELEOTRIS Gronow.

242. **Eleotris fusca** (Bloch & Schneider).

The scales in this species are 55–60 in longitudinal series. Its habitat is from the East Indies to Tahiti. It is not found in Hawaii, where it is represented by the small-scaled *Eleotris sandwichensis*. *Eleotris sandwichensis* Vaillant & Sauvage, of the streams of Hawaii, has 70 to 80 scales, but is otherwise identical with the present species.

Of this species we have four examples, from 3 to 4 inches long, from Sibuyan and Aparri (northern Luzon).

OPHIOCARA Gill.

243. **Ophiocara aporos** (Bleeker). *Pazo.*

Dorsal VI–I, 9; scales 30–34; scales on top of head large, about 15 rows in front of dorsal; maxillary reaching scarcely beyond vertical from front of orbit; posterior border of preopercle with two inconspicuous pores; a mid-lateral row of large spots on trunk and caudal peduncle, more or less confluent into a narrow band, of a width equal to diameter of eye; above is another indefinite series of similar spots; cheek and opercle crossed by three oblique bands of dusky, the upper band continuing lengthwise across the base of the pectoral, being bordered above and below by whitish, and fusing posteriorly with a transverse band of dusky which crosses the bases of the pectoral rays; dorsal and anal margined with pale; anal in males with a crimson band across base, outside of which, near middle of fin, is a narrower band, pale bluish in preserved specimens, probably violet in life; spots at base of pectoral indistinct in female.

Two specimens, a male and a female, 7 inches long, from Mindoro Island; a male 5 inches long from Sibuyan, and a large male, 8.50 inches long, from Camp Balete, Rio Baco, Mindoro (above tide).

Ophiocara hœdti (Bleeker) may not be different from this species.

244. **Ophiocara porocephala** (Cuvier & Valenciennes).

Dorsal VI–I, 8; scales 40–42; scales on top of head small, about 25 rows in front of dorsal; maxillary reaching vertical from middle of orbit; posterior border of preopercle with three large pores; scales of trunk for the most part each with a squarish dark spot at base; soft dorsal, caudal, anal, and ventrals edged with pale. Life colors: Black above; sides with slight green tinge; belly white, thickly speckled with dusky; dorsal, anal, and caudal narrowly edged with pale yellow.

One specimen from Mindoro Island, 4.50 inches long, and one from Calayan, in a brackish estuary, 6 inches.

A specimen of this species, taken at Calayan, was left dry for more than half a day, and revived upon being placed in water.

Ophiocara ophiocephala (Kuhl & Van Hasselt, in Cuvier & Valenciennes) is probably not distinct from the present species. *Eleotris ophiocephala* of Day is not this species, being a fish with a small mouth, and with the scales on top of head large, 15 in front of dorsal. The name *porocephala* has page priority over *ophiocephala*.

BUTIS Bleeker.

245. **Butis koilomatodon** (Bleeker).

Eleotris koilomatodon Bleeker, Verh. Bat. Gen., XXII, 1849, 21 (Cantor cited this memoir in his Catalogue of Malayan Fishes, giving it priority); Maduras Straits.
Eleotris caperatus Cantor, Cat. Mal. Fishes, 197, 1850; Sea of Pinang.
Prionobutis serrifrons Rutter, Proc. Ac. Nat. Sci. Phila., 1897, 84; Swatow, China.

Head 3.25; depth 4.30; eye 3.75; dorsal VI–9; anal 9; scales 29; superorbital crests strongly serrated; two anteriorly converging serrated ridges in front of each eye, as in other species of *Butis;* mouth oblique, making an angle of about 40 degrees with the horizontal axis.

Butis serrifrons is stated by Rutter to differ from *Butis caperatus* (Cantor) in having the mouth "nearly horizontal" (not "nearly vertical"), and in having two (instead of one) serrated ridges in front of each eye. In the type which we have examined the mouth cleft makes about 35 degrees with the horizontal.

As there are two ridges in front of each eye, even in those species of *Butis* (*butis*, *amboinensis*, etc.), which lack the strongly serrated orbital crests, it is doubtful whether Cantor's failure to describe more than one in *Butis caperatus* denotes the absence of the second. Cantor's estimation of the angle of the gape as "barely vertical" was evidently a comparative one, with reference to *Butis butis*. It may also easily have been influenced by the condition of the specimens.

One specimen, 2 inches long, from Iloilo.

The genus *Prionobutis* Bleeker is nominal, differing from *Butis* only in the more marked serration of the orbital crests. The species of *Butis* and *Prionobutis* agree in coloration, all having the black spot at base of pectoral, with the smaller white spots above and below.

246. Butis butis (Hamilton-Buchanan).

Cheilodipterus butis Hamilton-Buchanan, Fish. Ganges, 57, 367, 1822; Ganges. Gray & Hardwicke, Illus. Ind. Zool., II, pl. 93, fig. 3.

Eleotris humeralis Cuvier & Valenciennes, Hist. Nat. Poiss., XII, 246, 1837; Bengal.

(?) *Butis butis* Bleeker, Revis. Eleotriformes, 64, 1875; Sumatra, Borneo, Amboina, Philippines, etc.

Butis melanostigma Bleeker, Blenn. & Gob., 23, 1849; Maduras Straits. Bleeker, Revis. Eleotriformes, 68, 1875.

Eleotris butis Day, Fishes India, 316, pl. LXVII, fig. 3 (not good), 1878-88; Ganges. Günther, Cat., III, 116, 1861 (in part, only, perhaps).

Butis leucurus Jordan & Seale, Proc. U. S. Nat. Mus., XXVII, 1905, 794, fig.; Negros, P. I. Evermann & Seale, Bul. U. S. Bureau of Fisheries, XXVI, 1906 (1907), 104; Bacon and San Fabian, P. I.

Head 3 in length without caudal; depth 5; in total length, including caudal, 6; depth of caudal peduncle 3.30 in head; eye 5.50 in head, 1.50 in interorbital space; interorbital space 4 in head; maxillary 2.50 in head, greater than nose, extending past front of orbit under its anterior third; teeth small, in bands in both jaws, the outer ones slightly enlarged; dorsal VI–9; anal 9; scales 29; secondary scales present at base of large ones; color brown, with a few small spots on sides and under part of head, and scattered ones on body; scales of sides each with a pale spot at center, these appearing to form longitudinal rows; dorsals blackish, edged with pale; upper edge of caudal whitish, the rest dusky; anal blackish, with a trace of pale at edge; pectoral base with a black spot, above and below which are smaller white ones.

This species differs from *Butis amboinensis* (Bleeker) in its less slender form, its broader interorbital space, and in the presence of secondary scales at the bases of the large scales on the sides. From *Butis prismaticus* (Bleeker) it is distinguished by its shorter maxillary, rather coarser teeth, and slenderer caudal peduncle. The three species, *butis*, *prismaticus*, and *amboinensis*, all have the superorbital crests weakly serrated or crenulate, differing widely in that respect from *Butis* (*Prionobutis*) *koilomatodon* (Bleeker). The statement in the original description of *Butis leucurus* Jordan and Seale, that the superorbital crests are smooth, was apparently made in a comparative sense, with reference to the condition in *Butis koilomatodon*. It also seems that the interorbital distance in *Butis leucurus* was measured between the interorbital crests in the preparation of the original description of that species.

Of this species we have two specimens, one 3.50 inches long from Manila, and one 3 inches from Iloilo.

247. (?) **Butis prismaticus** (Bleeker).

(?) *Eleotris prismatica* Bleeker, Blenn. & Gob., 23, 1849; Maduras Straits.

(?) *Butis prismatica* Bleeker, Revis. Eleotriformes, 61, 1875.

Head 3 in length without caudal; depth 4 to 4.50; in total length, including caudal, 5 to 5.59; depth of caudal peduncle 2.80 in head; eye 6 to 6.50 in head, 1.65 to 2 in interorbital space; interorbital space 3.75 to 4 in head; maxillary 2.75 in head, slightly greater than nose, not extending beyond the vertical from front of orbit; teeth minute, in bands in both jaws, outer ones not enlarged; dorsal VI–9; anal 9; scales 29; secondary scales present; color as in *Butis butis*.

A specimen from Cuyo, 5.50 inches long, and one from Manila, 3.50 inches, are referred with some doubt to the present species. They are plainly distinguished from *Butis butis* by their shorter, more robust body, shorter maxillary, smaller eye, and finer teeth. Both the present species and *Butis butis* are easily separated from *Butis amboinensis*, which is a very slender fish, with narrow interorbital space, and without secondary scales.

248. Butis amboinensis Bleeker.

Eleotris amboinensis Bleeker, Bijd. Ichth. Amboina, IV, in Nat. T. Ned. Ind., V, 1853, 343; Amboina. Günther, Cat. Fishes, III, 117, 1861. (?) Day, Fishes India, 316, 1878–88; Bengal (probably not the same).
Butis amboinensis Bleeker, Revis. Eleotriformes, 66, 1875.

Head 3 in length without caudal; depth 5.50; in total length, including caudal, 6.75; depth of caudal peduncle, 3.60 in head; eye 5 in head, equal to interorbital space; interorbital space 6 in head; maxillary 2.50 in head, scarcely exceeding a vertical from anterior margin of orbit; teeth minute, in bands, none enlarged; dorsal VI–9; anal 9; scales 29; secondary scales absent; color brown, the back with 6 distinct cross bands and each side with an obscure longitudinal stripe of dusky, of the width of one scale; most scales of side with a post-central whitish spot, these spots forming rows as in *Butis butis* and *Butis prismaticus;* an obscure dark band across cheek and opercle, and a similar one on the snout, from eye to middle of maxillary; dorsals, anal, and ventrals dusky, anal blackish with pale outer margins; upper edge of caudal pale, rest blackish; pectoral paler, with a large black spot at base, with two smaller white ones in front of it, above and below.

Two specimens, 2.50 and 3.50 inches long, from Mindoro Island.

This species is readily distinguished from *Butis butis* and *Butis prismaticus* by its slenderer form, narrower interorbital space, absence of secondary scales, and different coloration.

HYPSELEOTRIS Gill.

249. Hypseleotris modestus (Bleeker).

Head 3.60; depth 4.25; eye 3.66; dorsal VI–10; anal 11; scales 29; a dark vertical bar across base of pectoral; a small caudal spot; no side stripe; fins pale, the spinous dorsal and caudal with faint brown specks.

A single specimen, 2.50 inches long, from Mindoro Island.

Bleeker states that this species has no specks on either dorsal fin. In our specimen the specks are very faint.

PERIOPHTHALMUS Bloch & Schneider.

250. Periophthalmus barbarus (Linnæus). (*Periophthalmus cantonensis* (Osbeck); *Periophthalmus kœlreuteri* Pallas; *Periophthalmus kalolo* Lesson.)

One specimen, 3 inches long, from Ticao Island, and one from Aparri, northern Luzon, 2.50 inches. Scales in Ticao specimen 82, in Aparri specimen 76.

These specimens seem to be identical with examples from Tokyo and with others from Samoa. It is doubtful whether more than one species of *Periophthalmus* proper can be defined. The specimens from Panay called *Periophthalmus chrysospilus* by Jordan & Seale are not different from *Periophthalmus barbarus.*

RHINOGOBIUS Gill.

(*Porogobius* and *Acentrogobius* Bleeker; *Coryphopterus* Gill.)

251. Rhinogobius nebulosus (Forskål).

Gobius nebulosus[a] Forskål, Descr. Animal., 24, 1775; Red Sea.
Gobius criniger Cuvier & Valenciennes, Hist. Nat. Poiss., XII, 82, 1837; New Guinea. Günther, Cat. Fishes, III, 29, 1861. Day, Fishes India, 288, pl. LXII, fig. 2, 1878–88.
Rhinogobius nebulosus Jordan & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 41; Cavite, Philippine Islands. Jordan & Seale, ibid., XXV, 1905, 401; Apia, Samoa.
Rhinogobius lungi Jordan & Seale, Bul. U. S. Fish Comm., XXI, 1901, 41, fig. 13; Panay, Philippine Islands.

Head 3.50; depth 4.60; nose 3.20; interorbital space .6 of eye; eye 3.40 in head; maxillary 2.75; dorsal VI–10; anal 10; scales 28; head and nape naked; body with four large roundish black blotches on each side, alternating with broad saddle-like dorsal blotches; nape with two broad bands of dusky, each broken up by vermiculate lines of pale; anal fin with a dark edge.

Five specimens from Manila 3 inches long, and one from Aparri 4 inches.

[a] This name is thought by Klunzinger (Fische Rothen Meeres, p. 479) to be perhaps a synonym of *Gobius caninus* C. & V. The latter species, however, lacks the black border of the anal fin, described by Forskål in *Gobius nebulosus.*

252. Rhinogobius baliuroides (Bleeker).

Head 3.60; depth 5.20; nose 3.60; maxillary 2.70; interorbital space .4 of eye; eye equal to nose; a recurved canine at each side of lower jaw; tongue entire; dorsal VI-10; anal 10; scales 27; nape, cheeks, and opercles naked; tail broadly rounded; spinous dorsal with a black bar across middle; broken cross bands on chin; under side of head without specks; color otherwise as in *Rhinogobius gymnauchen*.

This species is near *Rhinogobius gymnauchen* (Bleeker), of Japan, differing from it in its more rounded caudal fin and in its coloration.

Of this species we have a single specimen in excellent condition, 2.50 inches long, from Aparri, in Luzon.

We may here note that *Gobius calderæ* Evermann & Seale (fide Evermann, in lit.) has no silk-like rays in the pectoral. It is a species of *Rhinogobius*.

253. Rhinogobius caninus (Cuvier & Valenciennes).

Head 3.70; depth 4.30; nose 3.60; interorbital space 2.50 in eye; eye 4 in head; maxillary 2.50, extending under anterior third of eye; two (or one) canines in each side of lower jaw; dorsal VI-10; anal 10; scales 29; scales of nape very small, about 23 rows in front of dorsal; cheeks naked; opercles with a few small scales along upper margin.

Five large roundish spots of dusky on each side, alternating with obscure dorsal bar-like blotches; a dark blotch on shoulder, above opercle; pale roundish spots at center of scales, forming indistinct rows on sides; all fins more or less dusky; anal without dark edge.

Two specimens from Iloilo, a large female, 4 inches long, and a young example, 2 inches. A specimen from Lubang, 3 inches long (male), differs from the Iloilo specimens only in having fewer (about 16) rows of scales in front of the dorsal fin. It is possible that this may represent a distinct species.

GOBIUS Linnæus.

254. Gobius ornatus Rüppell.

One specimen 2.50 inches long from Ticao Island.

GLOSSOGOBIUS Gill.

255. Glossogobius giuris (Hamilton-Buchanan).

Gobius giuris Hamilton-Buchanan, Fishes Ganges, p. 51, pl. 33, fig. 15, 1822; Ganges.

Gobius giuris Günther, Cat. Fishes, III, 1861, 21 (in part only), *Gobius fasciato-punctatus* Richardson being the same as *Glossogobius brunneus* (Temminck & Schlegel).

Glossogobius giuris Smith & Seale, Proc. Biol. Soc. Washington, XIX, 79, 1906; Mindanao, not *Gobius giuris* of Rutter, which = *Glossogobius brunneus* (Temminck & Schlegel) nor of Abbott, which = *Rhinogobous giurinus* (Rutter). *Ctenogobius platycephalus* of Jordan & Evermann, from Formosa, is also identical with *Rhinogobius giurinus*. The original *Gobius platycephalus*, of Richardson, from Macao, is *Glossogobius brunneus*.

Head 3; depth 5; nose 3; interorbital space ½ eye; maxillary 2.30; eye 5.30; dorsal VI-9; anal 9; scales 30; nape closely scaled; cheeks and opercles naked; tongue forked; spinous and soft dorsal fins specked in the rays only; 5 large squarish blotches forming a lateral row on each side; above and below these, narrower, wavy longitudinal streaks of dusky, more or less broken; nape without spots; a dark spot at the upper part of the pectoral base.

Two excellent specimens from Mindoro Island, 6 and 7 inches long; one from Iloilo, 4 inches, and one from Aparri, 3.50 inches.

This species is very close to *Glossogobius brunneus* (Temminck & Schlegel), from which it differs mainly in the absence of the dusky bar across spinous dorsal, and the lack of spots on the nape.

AWAOUS Steindachner.

(*Chonephorus* Poey.)

256. Awaous ocellaris (Broussonet).

Head 3.33; depth 4.60; nose 2.30; maxillary 2.40; interorbital space .88 of eye; eye 6 in head (2.60 in nose); dorsal VI-11; anal 11; scales 55.

Five specimens from Mindoro Island, 3.50 to 4.59 inches long. These specimens agree essentially with examples from Samoa, differing only in having the body less uniformly darkened, and the spotting more prominent. Like the specimens from Samoa, they have the ocellus at back of spinous dorsal, and a spot on the upper part of base of pectoral.

AMBLYGOBIUS Bleeker

(*Odontogobius* Bleeker.)

257. Amblygobius phalæna (Cuvier & Valenciennes).

Colors in life: Dark green, the body with five light and five dark alternate bands, between each two of which is a narrow light blue band; three blue stripes on gill cover; a large dusky spot above upper angle of opercle; a similar spot on upper part of tail near base; first dorsal striped with cream and brown, a large dusky spot on its posterior portion; second dorsal margined with light yellow, blue black, and brown; belly pale blue; anal pale blue, like belly, margined with dusky; ventrals very pale blue, with dusky margins; pectoral clear pale yellow; caudal washed with salmon, dusky at tip.

A single specimen, 2 inches long, from Cagayancillo.

GOBIICHTHYS Klunzinger.

(*Pselaphias* Jordan & Seale.)

258. Gobiichthys tentacularis (Cuvier & Valenciennes). *Zapatero.*

Two specimens from Iloilo, 3 inches long, and one of the same size from Aparri, northern Luzon.

The genus *Gobiichthys* Klunzinger (*petersii*)) supersedes *Pselaphias* Jordan & Seale, the type of Klunzinger's genus having a tentacle over the eye. Except in this rather slight character, *Gobiichthys* does not differ from *Oxyurichthus* Bleeker as restricted in the present paper.

OXYURICHTHUS Bleeker.

The genus *Oxyurichthus* Bleeker (*belosso*) includes gobies with ventral fins united, tail lanceolate, dorsal fin short, an adipose nuchal crest, the upper teeth in one series, and the tongue convex. The species differ from those of *Gobiichthus* Klunzinger (*Pselaphias* Jordan & Seale) in lacking a tentacle over the eye, and from *Gobionellus* Girard in having the upper teeth in a single series, and the tongue convex. The type of *Oxyurichthus* was stated by Bleeker to have the upper pectoral rays silk-like, doubtless by error, none of the closely related forms of these genera known to us having them so. *Gobius papuensis* Cuvier & Valenciennes and *Gobionellus lonchotus* Jenkins are congeneric with the present species.

259. Oxyurichthus cristatus (Day).

A single specimen from Cagayancillo, 3 inches long.

APARRIUS Jordan & Richardson, new genus.

Aparrius Jordan & Richardson, new genus of Gobiidiæ (*acutipinnis.*)

This genus has the teeth very fine, in bands in both jaws, the tongue short, adnate nearly to tip, emarginate, and the tail acuminate, as in *Gobionellus*, in each of these characters differing from *Rhinogobius*. Like *Rhinogobius*, it has the scales large and the soft dorsal fin short. The name is from Aparri in northern Luzon, where the typical species is found.

260. Aparrius acutipinnis (Cuvier & Valenciennes).

Gobius acutipinnis Cuvier & Valenciennes, Hist. Nat. Poiss., XII, 80, 1837; Malabar. Day, Fishes India, 292, pl. LXI, fig. 2, 1878-88; Seas of India to the Andamans.
Rhinogobius ocyurus Jordan & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 42, fig. 14; Cavite, P. I.
Acentrogobius acutipinnis, Smith & Seale, Proc. Biol. Soc. Wash., XIX, 1906, 81; Mindanao, P. I.

Head 3.60; depth 4; dorsal VI-11; anal 11; scales 27; nose 3.50; maxillary 2; interorbital space .66 of eye; eye 4; teeth very fine, in bands in both jaws; outer teeth not enlarged; no canines; tongue short, adnate nearly to its tip, which is emarginate; cheeks and opercles naked; nape scaled, at least posteriorly; maxillary nearly to back of orbit; mouth scarcely oblique; first four rays of spinous dorsal (in female) prolonged, though scarcely filamentous, carrying the membrane nearly to their tips; the depressed longest spinous ray reaching to fourth ray of soft dorsal; soft dorsal high behind, the depressed fin reaching past base of caudal; caudal long, acuminate, its length less than 2.50 in length without caudal; anal reaching base of caudal; ventrals united, reaching nearly to vent; pectorals slightly longer than head, without silk-like rays.

Color in spirits dusky olive, with obscure cloud-like blotches, tending to form indistinct cross bands; nape vermiculated; a suborbital bar of dusky, dorsals and caudal specked in both rays and membranes; anal dusky, slightly darker toward margin; ventrals dusky, with pale edge; pectorals with a faint short bar across upper base.

Here described from a single specimen, 2.25 inches long (female) from Aparri, in northern Luzon.

This fish has the aspect of species of *Gobionellus* or *Oxyurichthus*, though differing from them distinctly in its generic characters. It has the notched tongue of *Gobionellus*, with the large scales of *Rhinogobius*. The Aparri specimen is referred to the present species with some hesitation, having perhaps a little less oblique mouth than the type of *Rhinogobius ocyurus* Jordan & Seale, and showing less plain traces of dark crossbars. The type of *Rhinogobius ocyurus* has the tongue destroyed.

WAITEA Jordan & Seale.

261. Waitea mystacina (Cuvier & Valenciennes).

Head 3.50; depth 4.50; nose 2.75; interorbital space .5 of eye; eye 4.20; maxillary 1.50, produced behind eye, to preopercle; teeth minute, in bands, as in *Gobionellus;* dorsal VI–11, the first three rays (in male) of the spinous dorsal much produced and finely filamentous, the filamentous extension of the third ray reaching beyond back of base of soft dorsal, anal 12; scales 29, head naked; caudal probably pointed (broken).

Color in spirits olive, bluish forward; sides with five distinct blotches; both dorsals mottled in the membranes; anal and ventrals dusky.

A single example (male), from Aparri, northern Luzon, 2.75 inches long.

SICYOPTERUS Gill.

262. Sicyopterus tæniurus (Günther).

Head 4.50; depth 5; eye 5.50 in head; dorsal VI–11 or 12; anal 11; scales 55–60.

One specimen from Mindoro Island, 3.25 inches long, and one from Sibuyan, 1.75 inches.

TRYPAUCHENICHTHYS Bleeker.

263. Trypauchenichthys typus (Bleeker).

Dorsal 59 (VII, 52); anal 49; scales 56, cycloid; ventrals notched three-fourths to base; color in spirits dull uniform light brown, with purplish tinge.

A single specimen from Cagayancillo.

GOBIOIDES Lacépède.

264. Gobioides brachygaster (Günther).

A specimen, 4.75 inches long, from Aparri is doubtless this species. It has the head 7.50 in length to base of caudal, not 9, as stated by Doctor Günther, but otherwise agrees with his description. Depth 12.50; dorsal VI, 45; anal 46; dorsal and anal separated from caudal by a notch; pectoral half the length of the ventral; eyes invisible; chin with numerous short barbels; head much wrinkled with sensory ridges; each side with a median lateral row of transverse vertical slits or pores, each surrounded by blue color.

Family SCORPÆNIDÆ.

SEBASTOPSIS Gill.

265. Sebastopsis guamensis[a] (Quoy & Gaimard).

Four specimens, 1.50 to 3 inches long, from Calayan.

SEBASTAPISTES Gill.

266. Sebastapistes nuchalis (Günther).

Head 2.50 in length to base of caudal; depth 2.75; depth of caudal peduncle 3.20 in head; dorsal XI, I, 10; anal III, 5 or 6; scales 38, the anterior 5 or 6 scales of the lateral line with a short spine; nose 3.66 in head; eye 4; interorbital space 1.50 in orbit; maxillary 1.90 in head, its tip reaching a vertical

[a] Two small specimens, 1.8 inches long, taken at Honolulu, H. I., in 1901, are apparently the young of this species.

from posterior margin of orbit; spinous armature of head well developed; a pair of sharp spines between nostrils in front of eye; each upper orbital rim with three spine-like serratures; posterior rim of orbit with two or three very small spines; two sharp "strong" spines in transverse series behind each upper posterior angle of orbit, and two in longitudinal series on each side of nuchal region; two strong spines at back of opercle, and three along upper margin of opercle, in a series continuous with the anterior spinous tubes of the lateral line; a strong humeral spine; a strong spine at upper angle of preopercle, with two weak spines in front of and above it, and four below it on the free preopercular margin; teeth in jaws in velvety bands, the posterior ones recurved; no barbels· orbital tentacles very small; a short nasal flap on each side; lower margin of preopercle with five or six small cirri; middle of each upper jaw with a short tentacle; scales of side without dermal flaps; pectoral 1.20 in head, with no prolonged or free rays; ventrals 1.40; caudal rounded, 1.50 in head; longest dorsal spine (fourth to seventh) 2.66 in head; second anal spine longest, two in head; lateral line complete; upper parts of cheeks and opercles scaled.

Color in spirits, grayish brown, mottled with darker; under parts little paler than upper; head darkest on lower part of cheek and at upper angle of opercle; edges of lower jaw and chin rather faintly marked with narrow dusky cross bands; spinous dorsal mottled, with a conspicuous black blotch in its upper part between the sixth and tenth spines, soft dorsal mottled, darkest in front and toward base, with a faint broad pale crossband at middle; caudal barred broadly with dusky across base, at middle, and behind; anal with an obscure broad bar across middle and on outer fourth; ventrals dusky, paler toward base; pectorals with scattered dark specks, forming an indistinct broad bar across inner third; axil of pectoral with several roundish white spots, smaller than pupil.

Two specimens from Calayan, 2.25 inches long. It is with hesitation that we refer these specimens to *S. nuchalis*, as the scales appear to be larger than in that species, and there are some differences in coloration and minute orbital tentacles. The species is near *S. ballicui* (Sauvage), but has a shorter jaw and much smaller orbital tentacles.

PARACENTROPOGON Bleeker.

267. **Paracentropogon longispinis** (Cuvier & Valenciennes).

A single example, 2 inches long, from Cuyo. The pale spot above the lateral line does not show in the specimen, which otherwise agrees closely with descriptions and figures of this species.

268. **Paracentropogon indicus** (Day).

A single small specimen from Cuyo, 2 inches long, agrees closely with Day's original description and figure of this species (Fishes of India, p. 155, pl. 38, fig. 2).

TETRAROGE Günther.

269. **Tetraroge barbata** (Cuvier & Valenciennes).

One example from Aparri, 2 inches long.

Family PLATYCEPHALIDÆ.

PLATYCEPHALUS Bloch.

270. **Platycephalus indicus** (Linnæus). (*Cottus insidiator* Forskål.)

One example, 8 inches long, from Manila.

THYSANOPHYS Ogilby.

271. **Thysanophys tentaculatus** (Rüppell). (*Platycephalus nematophthalmus* Günther, also of Bleeker.)

One specimen from Cuyo, 6 inches long.

Family PLEURONECTIDÆ.

PLATOPHRYS Swainson.

272. **Platophrys pantherinus** (Rüppell).

One specimen, 3 inches long, from Aparri, northern Luzon.

PSEUDORHOMBUS Bleeker.

273. Pseudorhombus javanicus (Bleeker).

Six specimens, 3 to 4 inches long, from Cavite, collected by Doctor Lung and recorded as *Pseudorhombus polyspilus* by Jordan & Seale, appear to belong to this species. They are distinguished from *Pseudorhombus arsius* (*russellii*) and *polyspilus* by their shorter jaw and wholly convex profile, without angle over snout.

274. Pseudorhombus polyspilus (Bleeker). *Dapa.*

One example, 4 inches long, from Iloilo, and one, 4.50 inches, from Manila. This species is apparently sufficiently distinguished from *Pseudorhombus arsius* (*russellii*) by the presence of numerous scattered small black specks on the body, each with a pale border.

275. Pseudorhombus malayanus Bleeker.

One specimen from Manila, 5.50 inches long. Dorsal 71; scales 85, ctenoid on both sides; traces of two dark spots on lateral line; color otherwise uniform.

In color this specimen resembles *Pseudorhombus oligodon*, which species, however, according to Doctor Bleeker, has fewer teeth.

Family SOLEIDÆ.

MICROBUGLOSSUS Günther.

276. Microbuglossus humilis (Cantor).

Four specimens from Manila, 1.75 to 2 inches in length.

BRACHIRUS Swainson.

(*Synaptura* Cantor, substitute for *Brachirus* on account of the prior *Brachyrus* and *Brachyurus*, restricted by Kaup to allies of *B. commersoni*.)

277. Brachirus sorsogonensis Evermann & Seale.

One specimen, 7.50 inches long, from Manila, and one, 6.25 inches, from Lubang.

CYNOGLOSSUS Hamilton-Buchanan.

278. Cynoglossus sindensis Day. *Dapa.*

One example, 10 inches long, from Manila. Dorsal 108; anal 86; two lateral lines on each side; scales cycloid on blind side.

279. Cynoglossus sumatrensis (Bleeker).

A specimen from Ticao Island, 2.75 inches long, is probably this species, although the angle of the mouth is a little farther forward than is said by Doctor Bleeker to be the case in *sumatrensis*. Dorsal 110; scales in lateral line (from base of nuchal branch) 70; transverse count between lateral lines on eyed side 11; a single lateral line on the blind side; scales ctenoid on both sides; color in spirits mottled brownish, with much the aspect of *Cynoglossus puncticeps*, from which it is easily distinguished by its much larger scales and longer dorsal fin.

Family PTEROPSARIDÆ.

PARAPERCIS Gill.

280. Parapercis tetracanthus Lacépède.

Two specimens from Calayan, 4 inches long. Color in life of upper parts brown, belly white; nine dark cross bands, extending downward nearly to median ventral line; head mottled with light and dark brown, white, and dusky green; dorsal sparsely and irregularly spotted with dusky; ventral and anal pale yellow; a large, well-defined, almost black area at base of caudal; beyond this a much smaller area of opaque white, about half an inch in length and including the middle ray and its two adjacent membranes.

281. Parapercis cylindrica (Bloch).

One example, 4 inches long, from Cuyo. Life color dirty white, with about ten wide vertical brown bars, which are wide at their middle and are united on the belly; top of head brown; dorsal light brown,

with spots of dark brown on membranes; caudal similar to dorsal; pectoral reddish brown; ventral dusky; anal light brown, spotted with darker brown and milky white.

Family BATRACHOIDIDÆ.

MARCGRAVIA Jordan.

282. Marcgravia diemensis (Le Sueur). *Guecguan.*

(*Cottus grunniens* Linnæus, "habitat in America," dorsal II–26, anal 22, is *Opsanus tau* or *Marcgravia cryptocentra*, and can not be identified with any Asiatic fish.)

Head 3.16 in length without caudal; depth 3.30; eye 4.75; interorbital space slightly greater than eye; nose somewhat less than eye, 4.50 in head; maxillary 2 in head, reaching a vertical from behind eye; opercular spines 4; three fringed tentacles above each eye; a fringe of small cirri on each side of upper lip, and a similar fringe encircling lower jaw; other smaller cirri on top of head and along margin of preopercle; dorsal III–19; anal 14; pectoral 1.4 in head; ventral 1.4; teeth in coarse villiform (molar-like) bands in jaws and on vomer and palatines.

Color brown, coarsely mottled, and speckled with darker; fins barred. Life color, dark, mottled with black, dark brown and gray, the gray forming three broken and irregular bands; belly, throat, and chin flesh color; pectoral strongly banded with gray and brown; a black band at base of caudal followed by five gray and four brown bands.

A single specimen, 3 inches long, from Cuyo.

This species is type of the genus *Coryzichthys* Ogilby, named but not defined in the Report of the Amateur Fishermen's Association of Queensland, 1907, p. 11.

Family CALLIONYMIDÆ.

SYNCHIROPUS Gill.

283. Synchiropus ocellatus (Pallas).

Head 3.30 in length without caudal; depth 5; depth of caudal peduncle 3 in head; width of head 1.16 in its length; eye 4 in head; nose 3.75; interorbital space equal to width of pupil; mouth very small, its width less than eye, the jaws subequal, the maxillary touching a vertical from anterior margin of orbit; jaws with minute teeth; preopercular spine with two curved hooks, directed obliquely inward; gill-opening as wide as pupil, superior, situated on the neck nearly midway between the preopercular spine and the base of the spinous dorsal; dorsal IV–8; anal 7; pectoral 1.3 in head, reaching past front of anal; ventral equal to head; caudal 1.16; lateral line complete, high, its course about an eye-width distant from the mid-dorsal line.

Color in spirits: Upper parts and sides brown; sides of head with numerous small ocelli (pale-encircled dark dots); sides of trunk marbled with grayish, the lighter color crossing the back in six crenulate-edged bands; lower part of side with about four roundish gray spots, each with smaller whitish specks about its circumference; other similar smaller white specks forming an indefinite row along outer edge of belly; middle of sides, between the marblings, with many small dark-encircled pale specks, of same size as the facial ocelli; spinous dorsal with three incomplete double-edged oblique crossbands, above which, between the first and third spines, is a row of four roundish ocellate black spots, each with a darker center and a pale edge; soft dorsal with two or three indistinct obliquish bands; caudal barred with dusky near base, pale submedially; its outer half obscurely double-barred, its posterior margin pale; anal dusky, paler near base, the rays tipped with whitish, ventrals twice barred broadly with blackish, tips pale; pectorals with three bands of small black spots in the rays; breast crossed by a vague, diffuse band of dusky; belly pale.

Two specimens, 1.50 and 2 inches long, from Calayan, in tide pools. On the life color, Mr. McGregor has the following note: "Brown, mottled with gray; tail with a few red spots; pectoral and ventral more or less orange; first dorsal with four conspicuous ocellate brown spots; snout and gill-covers and sides of face thickly speckled with blue."

Günther's *Callionymus microps*, the figure of which shows the spinous dorsal uniform black without ocelli, does not appear to differ in any important respects from the present species. The pectoral fins have fine, dark cross bars. *Synchiropus lili* Jordan & Seale, recently described from Samoa, is also

very close and may not be different. The pectorals are, however, clear, bright yellow, without bars. Mr. McGregor states that the pectorals of the present species are yellowish in life. Those of *Synchiropus lili* are bright yellow, edged with golden. It is not unlikely that both *microps* and *lili* are identical with *Synchiropus ocellatus*.

CALLIONYMUS Linnæus.

284. Callionymus sagitta Pallas.

Two young males, 1.50 inches long, from Manila. Dorsal IV-9; preopercular spine with four or five hooks directed inward and upward, and with a single strong spine in front pointing forward. Color in spirits brownish, with numerous darker ocelli; a row of dusky blotches along middle of each side; cheeks with small dark specks bordered with whitish; spinous dorsal blackish.

Family BLENNIIDÆ.

ENNEAPTERYGIUS Rüppell.

825. Enneapterygius philippinus (Peters).

Head 3.75; depth 5; depth caudal peduncle 3 in head; eye 3; dorsal III-XI, 8; anal 15; pectoral 2.75 in length without caudal; ventral 1.1 in head; caudal 1.4 in head; scales 30, 12 in lateral line; a pair of short nasal barbels; orbital cirri absent, or, if present, extremely small (not found by us).

Color in spirits pale straw, probably red in life; top of head, sides, and under parts more or less dusted with fine dark specks; two small spots of silver under eye; a large silver spot below front base of each pectoral, and a pair of similar small ones before base of ventrals; several splashes of silvery along lower portion of side, forming an indistinct row; second and third dorsals a little dusky outwardly; caudal faintly barred; anal pale; pectorals with distinct black specks in four series. A second, and smaller specimen, has the under part of the head and breast much more profusely specked, the anal uniformly dusky, and the caudal with a large, rather diffuse basal blotch.

This species is close to *Enneapterygius tusitalæ* Jordan & Seale, from Samoa, apparently differing from it chiefly in the presence of the silvery markings and in the reduction (or absence) of the orbital tentacle.

Two specimens, 0.70 and 0.80 inches long, from Calayan. The description of Peters differs only in that the type specimens from Luzon have the body marked by obscure dark cross bands.

PETROSCIRTES Rüppell.[a]

286. Petroscirtes eretes Jordan & Seale.

Petroscirtes eretes Jordan & Seale, Proc. U. S. Nat. Mus., XXVIII, 1905, 801, fig. 19; Negros, Philippine Islands. Bul. U. S. Bureau of Fisheries, XXVI, 1906 (1907), 47; Iloilo, Philippine Islands.

Petroscirtes vulsus Jordan & Seale, Bul. U. S. Fish Comm., XXVI, 1906, 47, fig. 20; Manila (young specimen).

(?) *Petroscirtes variabilis* Cantor, Cat. Mal. Fishes, 200, 1850; Sea of Pinang. Günther, Cat. Fishes, III, 234, 1861. Day, Fishes India, 327, pl. LXIX, fig. 7, 1878-88.

Head 4.20; depth 4.75; eye 3.50; nose 3.40; interorbital space 4.00; superior dermal flaps minute, there being two above each eye and one on each side of nuchal region; chin with a pair of well developed but small barbels, and a trace of a second pair (on one side only in this specimen); color in spirits, grayish brown, obscurely blotched and mottled; an indistinct dark stripe from eye to base of caudal fin, most prominent in front of pectoral, back of which it is nearly invisible, except when viewed at a favorable angle; dorsal with specks in the rays, these scarcely arranged in rows; caudal with an obscure V-shaped basal blotch; in life mottled with white and dark green, and with numerous points of pale blue.

One specimen, 2.50 inches long, from Cuyo.

This species is close to *Petroscirtes variabilis* Cantor, as figured by Day, and may not be different, although that species is stated by Günther to have no orbital tentacles. These are shown, however, in the figure by Day, although, on account of their small size, they are likely to be overlooked. Day states that specimens of *Petroscirtes cynodon* Peters (placed in the synonomy of *Petroscirtes variabilis* by Günther, sent to him by Doctor Peters, lacked the orbital tentacle. The present specimens show the dark lateral stripe of *P. variabilis*, a marking which apparently disappears readily, being difficult to make out in the cotypes of *P. eretes*.

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[a] *Petroscirtes azureus* Jordan & Seale, from Samoa, is probably not different from *P. tæniatus* (Quoy & Gaimard).

SALARIAS Cuvier.

287. Salarias rivulatus Rüppell.

Salarias rivulatus Rüppell, Atlas, Africa, 114, 1828; Red Sea. Jordan & Seale, Bul. U. S. Bureau of Fisheries, xxv, 1905 (1906), 429; Samoa.
Salarias quadricornis Cuvier & Valenciennes, Hist. Nat. Poiss., xi, 329, 1836; Ile de France. Günther, Cat. Fishes, iii, 255· Fische der Südsee, 209, taf. 117, fig. B, 1877; Upolu, Paumotu, Tahite. Klunzinger, Fische des Rothen Meeres, 486, 1871; Red Sea.
Salarias oryx (Ehrenberg) Cuvier & Valenciennes, Hist. Nat. Poiss., xi, p. 327; Red Sea.

Head 4.16; depth 4.50; depth of caudal peduncle 2.33 in head; eye 3.75; interorbital space 2 in eye; a pair of simple tentacles above orbits and on nape, each about half diameter of eye; nasal tentacles short, fringed; a crest on nape (in male) as high as half diameter of orbit; dorsal xii or xiii, 20; anal 23; pectoral 1 in head; ventral 1.3; dorsals of almost equal height, deeply notched; soft dorsal adnate to basal third of caudal.

Color in spirits, smoky bluish brown; the body with many narrow, vertical, obliquish, or zigzag streaks darker than the ground color, which is smoky brown; fins dusky, the dorsals crossed longitudinally by several (the spinous dorsal by three) oblique pale streaks; anal with at least one median longitudinal pale streak and with a very narrow outer edging of pale.

Two specimens, 2.50 inches long, from Calayan. These specimens, except for a very slight difference in the number of soft dorsal rays, agree very well with Günther's description and figure of *Salarias quadricornis* Cuvier & Valenciennes, and with the specimens obtained by Jordan & Kellogg in Samoa. Rüppell's *rivulatus* (var. *rivulatus* of Klunzinger) with elongate, black-edged, yellow spots, is said to represent a mere color variation of the probably more typical form called *quadricornis* by Cuvier & Valenciennes and Günther.

288. Salarias fasciatus (Bloch). *Palu.*

Head 4.60; depth 3.60; eye 3; orbital tentacles bi- or tri-branched; nuchal tentacles in the form of a fringed tuft, each with 6 or 8 projections; dorsal 31; anal 19; spinous and soft dorsals continuous.

Color in spirits brownish with blue wash; anterior dorsal region with numerous small bluish or dusky spots, these becoming elongate about middle of side and backward, where they form incomplete longitudinal streaks; traces of crossbands on hinder part of body, apparently continued upward more or less on soft dorsal; spinous dorsal mottled and spotted, with several rather large circular pale spots; caudal and pectorals with prominent specks in the rays, those on the pectorals quite squarish; breast crossed by a blue band; ventrals specked in the rays like pectorals.

One specimen, 3.30 inches long, from Cagayancillo. On the life colors of this specimen Mr. McGregor has the following note: "Mottled and lined with dark green and black; on side below posterior half of dorsal about twelve spots of sky blue; a few spots of the same color about eye."

The present specimen does not differ from the smaller one recorded by Jordan & Seale from southern Negros (Dean collection), nor from the example from Ishigaki, Riu Kiu, Japan, described as *Salarias ceramensis* Bleeker by Jordan & Snyder. It is possible that Bleeker's *S. ceramensis* is not different from the present species. Specimens of this species from Apia, Samoa, obtained by Jordan & Kellogg, have a row of blue spots,[a] each with a light center, on the upper part of the caudal peduncle, and have the fins, especially the caudal, more heavily marked than in the Philippine and Japanese specimens.

289. Salarias edentulus (Bloch & Schneider).

Head 4.50 to 4.75; depth 4.25 to 4.50; depth caudal peduncle 2.5 in head; eye 3.50; interorbital space 2 in eye; dorsal xi or xii, 21; anal 21 or 22; pectoral 1.1 in head; ventral 1.2; tentacles simple; no crest; dorsals rather deeply notched; back of trunk, tail, dorsals, and caudal fin with numerous small spots.

Two specimens from Calayan, 3.50 inches.

290. (?) **Salarias deani** Jordan & Seale (male (?), or new species (?)).

Head 4.60; depth 5.80; depth caudal peduncle 2.25 in head; eye 3.30; interorbital space 2 in eye; a single slender simple tentacle over each orbit, nearly as long as eye; no nuchal tentacles; nasal tentacles three- or four-branched; a moderate nuchal crest, as high as width of pupil (♂ ?); dorsal xii, 20; anal 21; pectoral 1.16 in head; ventral 1.50; dorsals both low, notched about halfway to base; longest dorsal spine 1.50 in head; longest ray 1.30; soft dorsal terminating above base of caudal; teeth uniserial in both jaws; no canines.

[a] In this respect agreeing with Günther's "variety" (specimen from Red Sea), Cat., iii, 245.

Color in spirits dark, smoky, bluish brown; caudal peduncle with traces of darker bands or blotches; head with fine punctulations; an oblong blue spot on each opercle (sex marking?); dorsals dusky in both rays and membranes, the spinous dorsal with three or four and the soft dorsal with eight or ten narrow longitudinal or obliquish and more or less zigzag streaks of darker; outer edges of both dorsals pale; caudal crossed transversely with zigzag bars of dusky, in places more or less mottled, or the light spaces taking the form of small circular spots; anal dusky, darker submarginally, and with a very narrow pale outer edge; pectoral pale, transparent, except for the six or seven middle rays, each of which bears one or two minute but conspicuous black dots about midway of its length.

A single specimen, 2.50 inches long, from Calayan.

This fish agrees substantially with *Salarias deani* Jordan & Seale in measurements, fin counts, etc., and in the absence of nuchal tentacles. The different coloration and the presence of a nuchal crest are apparently distinctive, but may be sexual characters of the male.

Family CONGROGADIDÆ.

CONGRODADUS Günther.

(*Machærium* Richardson, preoccupied; *Hierichthys* Jordan & Fowler.)

291. Congrogadus subducens (Richardson). (*Hierichthys encryptes* Jordan & Fowler.)

Head 6.50 in total length; 6.20 in length without caudal; depth at front of anal 1.75 in head; eye 5.30 in head, 1.50 in snout; maxillary 2.20 in head; teeth in lower jaw more than 40 on a side; dorsal 76; anal 65; pectoral 2.66 in head; dorsal beginning over posterior fourth of pectorals; anal beginning under twelfth ray of dorsal; scales more than 200 in a longitudinal series (240, estimated, on a count of ⅛); lateral line terminating under twelfth to fourteenth ray[a] of dorsal; cheeks scaled.

Color in spirits, light grayish brown, rather sparsely mottled and spotted with darker; a dark spot on opercle; dorsal and anal each with a basal row of dark spots. Life color: "Dark red, irregularly spotted with dark brown and mottled with gray; belly, throat, and chin marked with large white spots; a row of large dark spots along base of dorsal; dorsal, caudal, and ventrals pale, the membranes more or less regularly spotted with light reddish." (McGregor.)

Our three specimens, 7 to 9 inches long, all from Cuyo, agree with the description of *Machærium reticulatum* Bleeker, regarded as a synonym of the present species by Doctor Günther, who had both Richardson's type and specimens of *Machærium reticulatum* from Doctor Bleeker's collection. *Hierichthys encryptes* Jordan & Fowler, described from the Riu Kiu Islands from a young specimen in which all color has faded, is apparently not different from the present species.

292. Congrogadus hierichthys Jordan & Richardson, new species. *Tamayo.*

Head 5.75 in length to base of caudal; depth at front of anal 1.3 in head; eye 5 in head, 1.60 in nose; maxillary 2.50 in head; lower jaw somewhat longer than upper, the teeth on one side between

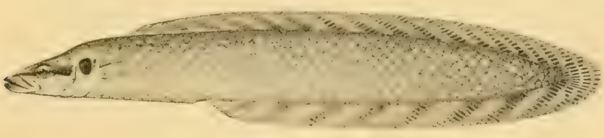

FIG. 11.—Congrogadus hierichthys, new species. Type.

25 and 30; dorsal 57; anal 46; pectoral 2.60 in head; dorsal beginning over tip of pectoral; anal beginning under tenth ray of dorsal; scales 160; lateral line terminating under sixth or eighth ray of dorsal; cheeks scaled.

Color in spirits nearly uniform brownish, vaguely mottled and clouded with darker; a conspicuous roundish black spot on opercle, a little smaller than eye, surrounded by a narrow border of pale; a

[a] Not running the whole length of body, as wrongly indicated in Richardson's figure, an error which led to the establishment of the nominal genus, *Hierichthys*.

dark band across cheek and through eye; a row of black specks on each side of top of head and a similar row along posterior margin of preopercle, these marking the openings of pores; dorsal and anal with dark spots in the membranes, in four series in the dorsal and in three in the anal. Color in life: Dark brown; head dark greenish, lighter below; side behind gill-opening and side of head with a few white spots; on opercle a large black spot narrowly bordered with yellow; dorsal, caudal, and anal light brown, membranes spotted with darker brown.

(*Hierichthys*, a generic name proposed by Jordan & Fowler, identical with *Congrogadus*).

Two specimens from Cuyo, 3 and 4 inches long. The type is no. 20208, Stanford University; the cotype is no. 61684, U. S. National Museum.

Family BROTULIDÆ.

DINEMATICHTHYS Bleeker.

293. Dinematichthys iluocœteoides Bleeker.

Head 4 in length, without caudal; depth 5.30; eye 3 in nose; dorsal 82–85; anal 56–59; pectoral 1.40 in head; ventral 1.25; caudal separate; a prominent anal papilla and a pair of horny claspers; scales about 100; cheeks scaly; opercle with a spine at its upper angle, pointing backward, and another shorter and blunter one at about middle of its posterior margin, directed obliquely downward.

Color in spirits grayish brown; head, body, and vertical fins along their bases finely punctulated with dark specks.

Two specimens from Ticao Island, 2 inches long. These specimens agree with Samoan examples in having the anal rays under 60, and not 69, as stated by Bleeker and Günther, probably by error.

Family ANTENNARIIDÆ.

ANTENNARIUS (Commerson) Lacépède.

294. Antennarius chironectes (Lacépède).

A single specimen from Cagayancillo, 3 inches long.

295. Antennarius lithinostomus[a] Jordan & Richardson, new species.

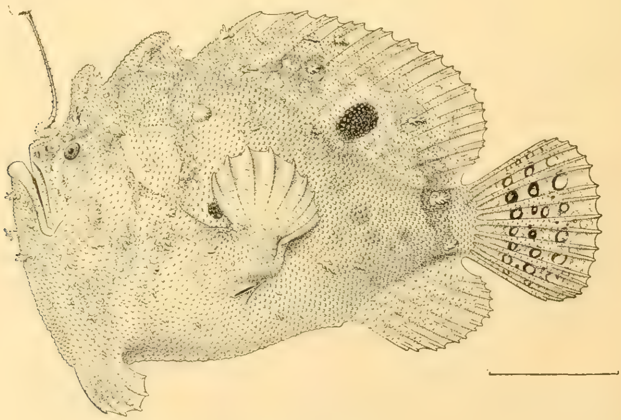

FIG. 12.—Antennarius lithinostomus, new species. Type.

Depth 1.60; width 3.2; body and fins everywhere roughened with wart-like asperities, which are typically bifid; sides with a few larger and fringed dermal flaps; two fringed flaps behind the angle of the maxillary, one directly below it, and one in front of the posterior fourth of the mandible; three

dermal flaps, set in a triangle, on chin below its middle; eye 4.75 in length of maxillary; interorbital space 3 times eye; maxillary 4.2 in length, nearly vertical; "fishing-rod," or prolongation of first dorsal spine, twice the length of the second dorsal spine, 1.2 times length of maxillary; second dorsal spine 2.2 in maxillary, the depressed spine reaching halfway to tip of third dorsal spine; dorsal rays in continuous dorsal fin 13, the longest rays as long as the middle rays of caudal; anal rays 7, the longest ones .8 of longest dorsal rays; last rays of dorsal and caudal connected by membrane with caudal peduncle fully to base of caudal rays; depth of caudal peduncle 1.9 in length of maxillary; pectoral reaching vertical from fifth anal ray; horizontal spread of ventrals 2.3 in length of fish to base of caudal; gill-opening under base of pectoral; teeth strong, in a broad band in each jaw, directed obliquely backward.

Color in spirits grayish olive, with some black marblings, blotches, and ocelli; a large black ocellus on base of eighth dorsal ray, twice diameter of eye; two round black spots larger than eye above and behind base of pectoral; head, trunk, and all fins except caudal with obscure, faded marblings; caudal with three transverse rows of conspicuous black ocelli, each with a transparent center; tongue and inside of throat marbled like front of chin and trunk.

The life colors are thus described by Mr. McGregor: "Mottled and blotched with dark brown and gray; lips grass green; dorsal, caudal, and anal largely green; a pink spot above pectoral; the whole fish with the appearance of an alga-covered rock, even the interior of the mouth being mottled."

One specimen from Cuyo, 4 inches long; the type is no. 20204, Stanford University.

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[a] λίθινος, marbled; στόμα, mouth.

GENERAL INDEX.

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